MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 60 NUMBER 12

Contents for December, 1938

THE COST OF APPRENTICESHIP . . . . . *Warner Seely* 901
UNTANGLING THE CORPORATE HARNESS . . . *Marvin Bower* 904
PROGRESS IN RAILWAY MECHANICAL ENGINEERING, 1937–1938 . . 909
JOB EVALUATION:
I—AN ANALYSIS OF THE SEVERAL PLANS IN USE TODAY *J. E. Walters* 921
II—A SPECIFIC APPLICATION . . . . . *A. W. Bass, Jr.* 927
HARD-SURFACING PROCESSES AND MATERIALS . . *M. L. Begeman* 931
CONTROL OF DUST EXPLOSIONS IN INDUSTRIAL PLANTS . *H. R. Brown* 936
DEVELOPMENT OF THE SHEARING OF TEXTILE FABRICS . *R. L. Marble* 939
FOUNDRY METALS:
CAST STEEL OR WELDING? . . . . . *F. A. Lorenz, Jr.* 943
HIGH-STRENGTH GRAY IRON . . . . . *A. C. Denison* 945
MALLEABLE IRON CASTINGS . *Enrique Touceda and J. H. Lansing* 946
ENGINEERING'S PART IN THE DEVELOPMENT OF CIVILIZATION—VI . . . . . *D. C. Jackson* 949
"THE INDUSTRIAL WORKER" . . . . . *E. R. Livernash* 954
E.C.P.D. TAKES STOCK AND PLANS FOR THE FUTURE 957
A.S.M.E. HONORS AND AWARDS—III: THE JUNIOR AND STUDENT AWARDS 963

EDITORIAL 899
BRIEFING THE RECORD 967
LETTERS AND COMMENT 978
A.S.M.E. BOILER CODE 981
REVIEWS OF BOOKS 982
A.S.M.E. NEWS 985

INDEX TO ADVERTISERS 48

OFFICERS OF THE SOCIETY:

HARVEY N. DAVIS, *President*

W. D. ENNIS, *Treasurer* C. E. DAVIES, *Secretary*

PUBLICATION STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*

COMMITTEE ON PUBLICATIONS:

M. H. ROBERTS, *Chairman*

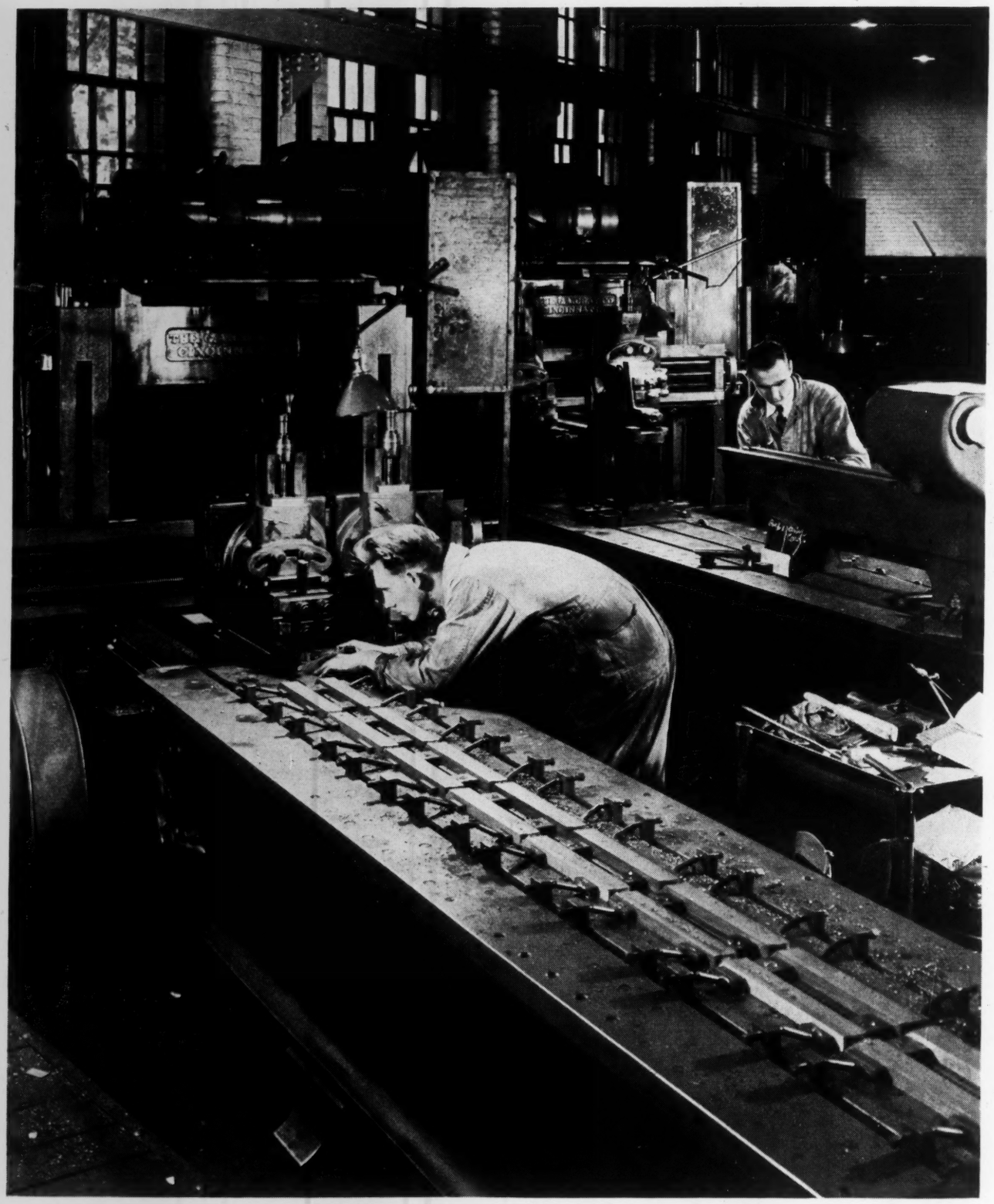
G. F. BATEMAN COLEMAN SELLERS, 3D

C. B. PECK F. L. BRADLEY

ADVISORY MEMBERS OF THE COMMITTEE ON PUBLICATIONS:

W. L. DUDLEY, SEATTLE, WASH. A. N. GODDARD, DETROIT, MICH. E. J. KATES, NEW YORK, N. Y. L. S. MARKS, CAMBRIDGE, MASS. J. M. TODD, NEW ORLEANS, LA. Junior Member, A. E. BLIRER, EDGEWATER, N. J., AND R. F. WARNER, JR., NEW YORK, N. Y.

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1938, by The American Society of Mechanical Engineers. Member of the Audit Bureau of Circulations.



Planers Furnish Training Jobs for Apprentices

(*See paper "The Cost of Apprenticeship," pp. 901–903 of this issue.*)

VOLUME 60
No. 12

MECHANICAL ENGINEERING

DECEMBER
1938

GEORGE A. STETSON, *Editor*

A.E.C.'s Impressive Program

TO ITS many achievements the American Engineering Council added another success on Armistice Day by holding in the City of Detroit the second of its forums, which was devoted, in this instance, to a discussion of the subject, "Invention and the Engineer's Relation to It." In an effort to be of greater service to the profession and to the nation, and conscious of the fact that under its traditional procedure the average individual member of the organizations that make up the Council have no opportunity to see it in action by attending public meetings, the American Engineering Council, last May, dusted off its chairs, opened its doors, and invited engineers to come in and participate in a forum on unemployment and the engineer's relation to it. Actually the chairs and doors were those of the Engineers' Club of Philadelphia, through whose hospitality the Council was able to put on a show outside its Washington headquarters. Thus some two hundred engineers, most of whom had never before seen A.E.C. in action, gained a first-hand knowledge of its purposes and methods and of the caliber of its leaders. The proceedings were subsequently published in a useful pamphlet.

At Detroit, on November 11, another group of 200 engineers participated in the second forum, for which the Michigan Engineering Society acted as sponsor. The papers read at Detroit maintained the high standard set at Philadelphia, and the discussion was even better. Announcement was made that papers and discussions would be available in printed form. A third forum is to be held in Washington, January 12 to 14, 1939, in connection with the 1939 annual meeting of the Council.

The significance of the Detroit forum on patents calls for comment. Economic institutions are under attack in the United States. Last January, at the A.E.C. meeting in Washington, Senator O'Mahoney made a vigorous plea for federal incorporation of business enterprises. Today Senator O'Mahoney heads the so-called "Monopoly Committee," correctly known as the Temporary National Economic Committee, established by resolution of the last Congress. Although fears were originally expressed that the committee would exercise a political influence in the 1938 elections, the committee took no such course, and the opinion is now generally held that the work of the Committee will be a careful and accurate study of the system of American enterprise. Many independent institutions and persons are endeavoring to provide the committee with facts and opinions relevant to the impending study; such, for example, as the now famous Berle memorandum recently much discussed in the newspapers. It was said at Detroit that the subject of patents is at the top of the list to be considered by Senator O'Mahoney's committee. The alertness of the American Engineering Council in providing a forum in which the attention of engineers could be focused on patents and thus minister to the public good marks another example of the enterprise, leadership, and usefulness of this medium for united effort on the part of engineers.

The American Engineering Council has earned for itself an enviable reputation in Washington, in the country at large, and in the profession through the concrete public services it has rendered in special studies with which it has been associated: Twelve Hour Shift in American Industry (1920), Waste in Industry (1921), Business Cycles in Unemployment (1922), Industrial Coal—Purchase, Delivery, and Storage (1923), Civil Aviation (1925), Safety and Production (1926), Street Traffic Signs, Signals, and Markings (1927), Recent Economic Changes (1928), Airport Drainage and Surfacing (1930), and Survey of the Engineering Profession (1934).

Without its routine functions as the "Washington Embassy" of the engineering profession and without the work of its voluntary committees (which are concerned with operation of the Council, public affairs, and engineering economics) the achievements to date just listed provide convincing evidence that support of A.E.C. efforts by the engineering societies is an investment in national prestige that the profession is wisely making. Such support enhances the strength and unity of the engineering profession. But it is not enough to rest on past achievements. Such forums as have been held in Philadelphia and Detroit should continue as long as they serve a useful purpose, and ways and means must be found to continue the series of special investigations, already noted, that began in 1920. As a case in point, an able fact-finding report on the patent situation, conducted by the A.E.C., would command the respectful attention of the Monopoly Committee and be of inestimable value to American enterprise.

It is such an opportunity as this that engineers have it in their power to seize by wholeheartedly backing the American Engineering Council. Undoubtedly, this country is facing a period of economic recovery, but a recovery which will take place in an atmosphere of new concepts of industrial responsibility and of new efforts to devise mechanisms of control and regulation. The

fate of engineering is tied up with that of industrial enterprise and economic stability. Administration officials and government bureaus in Washington will be seeking more than ever before what advice engineers can offer them. They have learned to turn to the A.E.C. in the past, and because of the character of the service A.E.C. has rendered, they will continue to turn to it in the future.

Engineering societies, that were organized to concern themselves principally with the technical developments of their several areas of interest, have extended those interests, as a result of the depression and a general public awakening to the importance of social and economic questions, to include the welfare of the individual engineer, of the profession, and of the world of which they are a part. When this period of broadening interest developed, American Engineering Council was able to provide a means for unity of action by the profession. In their own spheres of influence and jointly through A.E.C., the national engineering societies seized the opportunity to exercise the same leadership in public affairs and in matters relating to the welfare of the profession that they had exercised for generations in technical developments. It is most important for these societies that they retain this leadership.

Here, then, is evidence of the significance of the achievements of the American Engineering Council. In this broad field of joint action for the benefit of the nation and for the welfare of the engineering profession lies its continuing opportunity.

Impact of Science

ON THE NIGHT of October 30 the American people had a chance to find out something about themselves and what they found out is not pleasant to contemplate. Their old friend of home and fireside, the radio, put on a witch-doctor's mask and instantly three thousand years of civilization slipped off the child of science and he collapsed in fear of things his reason would have told him were preposterous. Mr. Orson Welles provided a striking demonstration of the "impact of Science on Society" in his fantastic broadcast.

Of the dozens of morals, lessons, and safeguards that will doubtlessly be reaped from this experience it is difficult to make a forecast, but through them all remains the ugly fact that the thing actually happened in this year of grace 1938 when every child is educated at public expense, lives in an environment conditioned by applied science, and has explained to him the mysteries of natural phenomena that used to hold people in the grip of fearful ignorance. To what advantage the unscrupulous may, with the aid of the stage settings of science, turn unreasoning credulity, cannot be predicted. It is pleasanter to remember the manner in which the people of New England faced the age-long natural terror of hurricane and flood that not only brought to them recently the disaster and destruction that has always accompanied such visitations but played havoc with those now essential services of applied science upon which modern living has become dependent. One hopes that real troubles will be faced with the fortitude and intelligence called forth by the hurricane and not the panic and hysteria aroused by the dramatization of a ghost story.

Change in Engineering Attitude

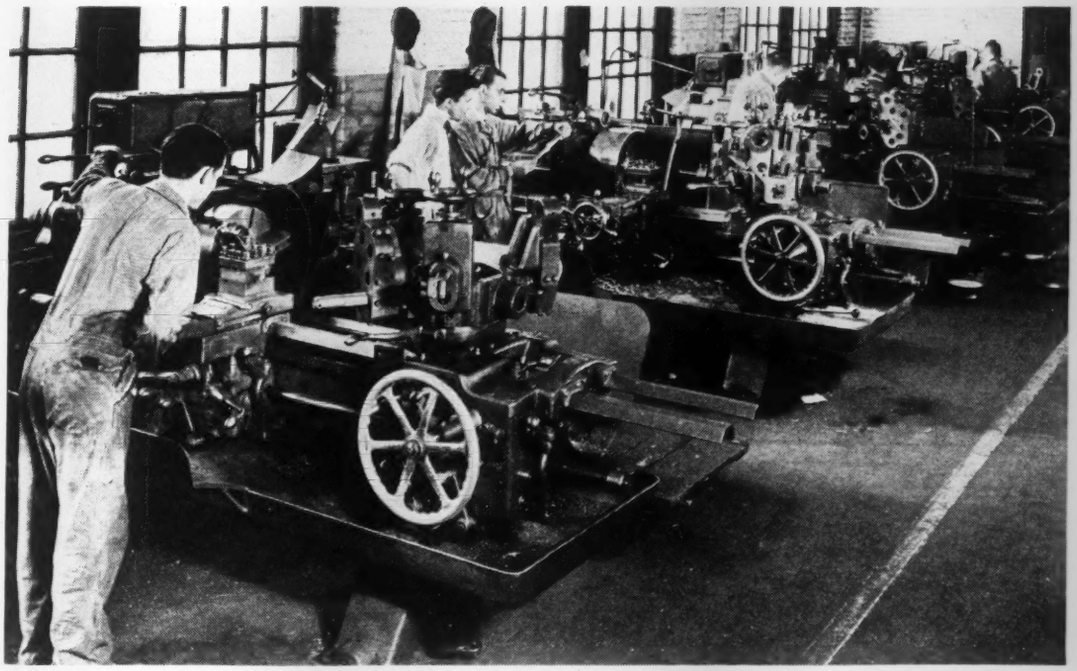
COMMENTING on the recent International Congress of Applied Mechanics as giving evidence of the "decline of cookbook engineering," Norbert Wiener, of M.I.T., writes in the November issue of *The Technology Review:*

"It is an interesting reflection that the entire morale of engineering in fields apparently remote from aeronautics has been raised and stiffened by the development of the airplane. The airplane is a structure which very nearly fails to work, and only by supreme intelligence in design can it be made to work even in an approximately satisfactory way. The result is that good old-fashioned cookbook engineering, which went by rule of thumb and covered up all incompetencies of design by a bang-up big factor of safety, has gone into the discard. However, the new investigations arising out of aeronautics are quite as useful in old fields of work. Economically speaking, aeronautical research has paid the overhead for a general improvement of engineering research all along the line."

Assault on the factor of safety began when it became recognized that it was, in reality, a "factor of ignorance." The method used in carrying forward the assault has been that of research. Factor of safety lost some of its smug respectability when it was dubbed factor of ignorance; and scientific research is now supplanting that ignorance with knowledge.

This all fits in quite neatly with Mr. Wiener's second point, and brings us back to the A.S.M.E. Annual Meeting program. Here we note how the methods that have been successful in purely engineering problems are bearing fruit in diverse fields. Who would have thought, a generation ago, of including physiology, psychology, and philosophy on an engineering program? In a definition of engineering published a couple of months ago Karl T. Compton introduced biology. The careful studies in management initiated by Fred Taylor are extended into such subtle fields as those of Dr. Whitehead, reported by Mr. Livernash on page 954 of this issue.

What are we coming to? From collateral and remote fields we are introducing new thoughts and techniques into engineering. The tables are turning. Instead of the impact of engineering on society we are witnessing the impact of social and economic change, as well as science, on engineering. The engineer of the future will not only drive the factor of safety down to the vanishing point, but he will enrich his profession and understanding by dispelling an ignorance he previously considered unsignificant by a useful knowledge drawn in from external sources.



GROUP OF APPRENTICES IN TURRET-LATHE DEPARTMENT, WITH APPRENTICE INSTRUCTOR

The COST *of* APPRENTICESHIP

By WARNER SEELY

THE WARNER & SWASEY COMPANY, CLEVELAND, OHIO

APPRENTICESHIP involves so many intangibles that it is seldom discussed calmly and frankly in terms of cost by executives who have the power of decision. The common approach is either a friendly, sentimental one or a hostile, blustering attitude which blindly refuses to believe that training can be carried on without fuss and great expense.

I ask myself: "What would it have cost our company if we had *not* had a system of apprentice training throughout our many years of operations in the machine-tool and instrument business?" We dug out our old apprentice-training records, intent on finding out just what the graduates of our training course had contributed to the business through these many years. What did we find? We found that graduates of our regular four-year training program have filled every major production post in the entire company. Today there are 85 graduate apprentices in shop, executive, or sales positions with the company. They include our works manager, our works engineer, our chief designer, our chief metallurgist, a number of district sales managers and representatives, and innumerable demonstrators, foremen, and inspectors.

At the same time we found, outside our own organization, four graduate apprentices who are at present the presidents and vice-presidents of as many major machine-tool and metal-working companies, one who is assistant fire chief in our community, another who serves as financial director of a national philanthropic agency, and chief inspectors, time-study chiefs, and other men in similar capacities with various other companies. Continued contact between such men and businessmen on the outside has established the potency of their influence in building goodwill toward and a broader knowledge of our company.

In short, *we are what we are* largely because of the degree to which we have trained men through full periods of apprenticeship—whatever the literal cost in years past may have been.

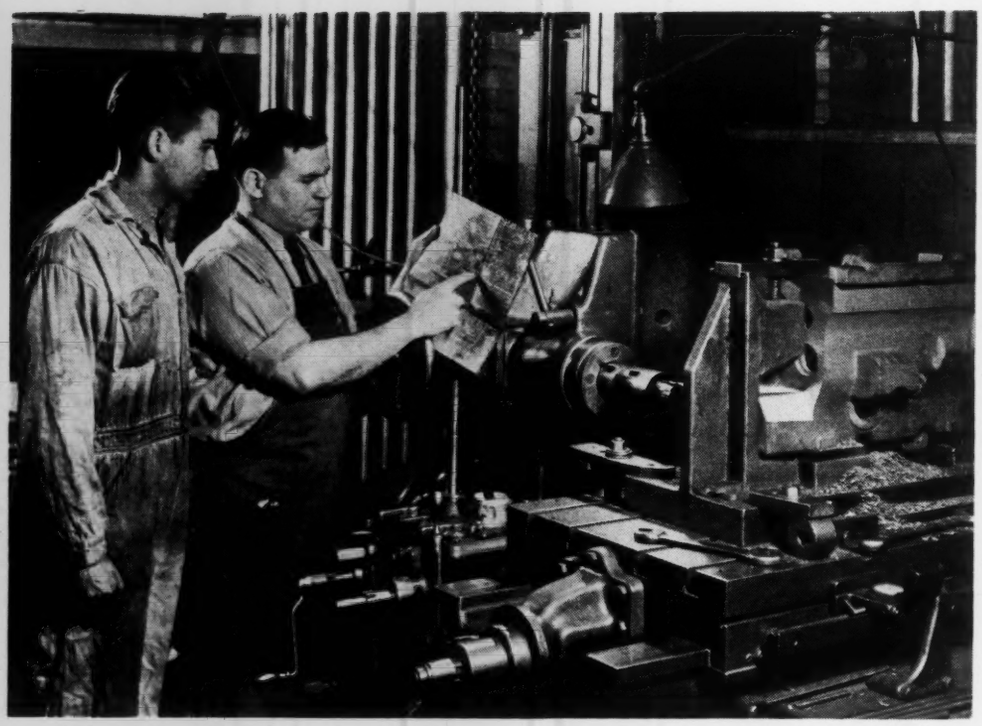
BASIS OF FACTS AND FIGURES NECESSARY FOR VALID PROGRAM

Today, however, one finds that the organization of apprentice training in every metal-working industry which takes the matter seriously is founded on engineering facts and figures which take actual training costs and specific long-term employment requirements fully into account.

"How many men can we absorb for training in our own production organization?" those in charge of planning any sound training program must first inquire. "What is the company's need for trained men over a period of years? What special costs will be entailed in the thorough supervision of trainees, and with what numbers will the whole program work out most efficiently?" Not until such questions are adequately answered can the foundations necessary for a valid program be laid.

It was the total absence of searching inquiry along these lines that placed so many training programs in bad odor among the chief executives of responsible corporations in years gone by. In days like these we cannot expect to gain sympathetic consideration of management for training programs by arguing,

Contributed by the Committee on Education and Training for the Industries for presentation at the Annual Meeting, New York, N. Y., Dec. 5–9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



APPRENTICES IN FINAL YEAR ARE ASSIGNED ADVANCED WORK —BOY RECEIVING INSTRUCTION ON BORING MILL

as I may seem to have done in referring to our graduate apprentices, that the end justifies the means. The freedom with which many an enlightened management has swung the ax on training programs in its efforts to modify the impact of general business difficulties has proved beyond any doubt that training must stand on its own feet to survive.

What are the elements of such a self-sustaining program? First and foremost, it seems to me, is the need to analyze all the potential contributions of apprentice training to the company concerned. It is not enough merely to budget training on a basis of shop vacancies. Certainly, if this were so, the increasing porportion of jobs requiring simple repetitive work might prove conclusively that there is a shrinking need for men of all-round skill. Today, the startling advances in all of our machine industries require more and more background of personal skill for the man who goes out to sell. There is a crying need for mechanically trained men above the wage-earner group in almost every branch of the metal industries, and a well-rounded apprentice-training program is probably the best means of supplying men to meet these higher responsibilities.

The careful selection of trainees, bearing all the foregoing facts in mind, is basic to the success of any program. Unless those selected manifest superior mental qualities as well as manual skills, the chance of their developing the executive abilities and personalities essential to fulfillment of such advanced responsibilities is doubtful. Under the law of averages a carefully selected group, chosen after conferences between the company's personnel manager and its training director, may yield some men who never advance beyond the status of skilled, all-round machine operators, but the majority will develop the capacity for leadership and personality, as well as an understanding skill.

Execution of the actual training program presupposes a careful analysis of shop training opportunities available for the gradual development of skills; a thorough understanding of related subject matter which trainees will have to learn to meet the needs of the particular employer; and a recognition of the need for training in broader social and economic fields, without which proper balance cannot be insured. Given a proper understanding of all these elements, it is possible to establish an all-embracing program, with standards fixed to maintain fundamental requirements but allowing flexibility enough to accommodate individual capacities, unusual skills, and particular interests. Such standardization does not mean regimentation in any sense. It merely insures performance by trainees at a level which accomplishes the training objective and returns a quantity of productive work sufficient to support and immediately justify the program.

APPRENTICES PRODUCE ENOUGH IN THE SHOP TO PAY THEIR WAGES

As far as I know there are no general figures available on the cost of apprentice training, so I take the liberty of referring to our own company and its experience. Speaking specifically of our experience since the reestablishment of our 51-year old training program after a brief and regretted interruption in the three worst depression years, I can state that it has not added a dollar to our expense of doing business. Our apprentices, averaging 45 in number, have been producing more than enough in the shop to pay their own wages (an average of 45 cents an hour), for four hours of school time, as well as 36 hours of shop time each week. Their actual production is more than enough to carry this, plus the expense of supervisory salaries and of special tuition at Case School of Applied Science when work is slack. We feel that we could even charge a portion of foremen's salaries to the program in recognition of time spent in assisting apprentices, and still break even.

Careful analysis of shop performance developed the fact that there is a loss of 9 per cent in production through the lower efficiency of trainees and my calculation takes this into account. Also, as the accountants would remind us, there is a corresponding loss in overhead on all equipment in use by apprentices, but our study recognizes that, too. Thus we have sought out every cost, both actual and hidden, to learn just where we stand. And with it all, our apprentices are drawing wages which they

recognize as proper and adequate. Starting at 37½ cents an hour, they are advanced 2½ cents an hour every six months during the four-year period, which brings them to a maximum apprentice wage of 57½ cents an hour, and this becomes 65 cents at the time of graduation.

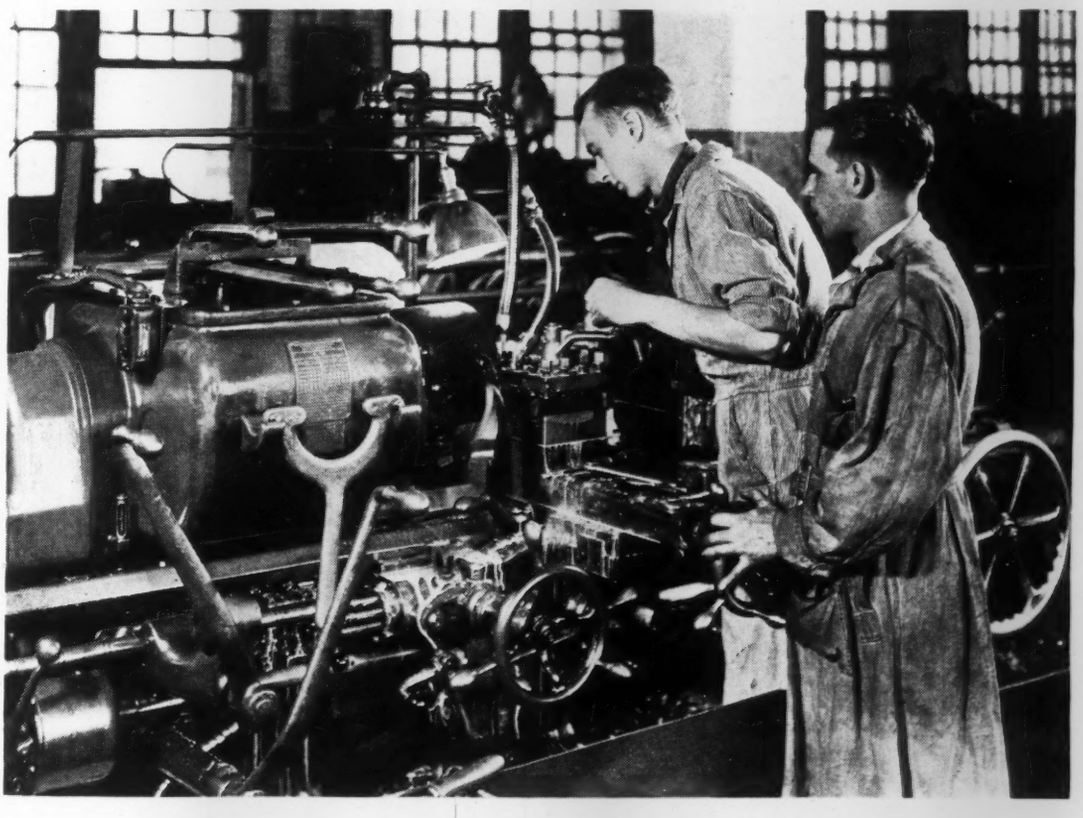
Much as the money means, the opportunity to participate in a well-established and widely recognized apprentice course is even more sought after. If the program is well-planned and thorough, completely organized and intelligently supervised—if it represents an open door to opportunities all the way up the line to major production, sales, and executive positions—the number of quality applications is sure to be far in excess of the company's own training capacity. This may make the process of selection more difficult but it certainly affords the broadest possible opportunity to establish contacts with applicants of greatest promise.

A FEW PLANTS CARRY THE APPRENTICE-TRAINING LOAD

Offsetting this advantage, however, is the fact that those companies who are carrying the load—training men to meet their own anticipated needs—are actually supplying leadership to many other firms who could and should be carrying on training programs of their own. This fact has been particularly true in the machine-tool industry for many generations, during which automotive, aircraft, implement, and most other fields in which precision operations are all-important have relied on it to do their training. If it is set up with a solid groundwork of facts and figures at the outset, any training program can be made to carry itself along by the time its four-year course gets into full swing. The trouble in the past has been that too many manufacturers have gone blindly into training, entirely ignorant of its human engineering and production implications. Experience has proved that it is not a fancy frill. It is a real aid to production and a genuine asset. Today, it is a vital necessity. We must recognize it and act on it. More than that—we must stick with it, through good times and bad, for the desired long-term results cannot be obtained if the whole program is to be thrown out at the first sign of declining business.

I have not discussed the obligations of industry—the prime mover in our modern civilization—to the young people of our land, particularly with respect to training them for a productive, useful life. Public-school systems throughout the country have manifested a growing interest in these problems of vocational adjustment, moving largely on their own initiative without the aid or counsel of private industry. The government itself is edging in, having set up bodies like the Federal Committee on Apprenticeship under the jurisdiction of the United States Department of Labor, largely because private industry has made no move to meet these obligations in any satisfactory, all-embracing manner. I am confident that these public agencies are sincerely trying to meet a very real and clearly established need, but this should be met by industry itself. Unless the employers of America knuckle down to the business of training in a serious way, we may soon find the federal government giving orders which private industry would have to obey. We cannot afford to sit idly by, particularly when a golden opportunity awaits us. We all know that the whole country is alive to the problems of training; that school systems are trying as best they can to develop programs which will fit their pupils for constructive service in our complex society.

If industry will but take the initiative, organizing its own internal training programs, if need be, along cooperative community lines, it can set the pace for all these related activities. It is industry's job to lay out the pattern so that all the other agencies striving toward a more intelligent mobilization of human capacities can cut their cloth to fit.



INSTRUCTING A NEW BOY IN TURRET-LATHE OPERATION

UNTANGLING *the* CORPORATE HARNESS

By MARVIN BOWER

McKINSEY, WELLINGTON & COMPANY, NEW YORK

NOT LONG AGO I had occasion to discuss organization problems with a vice-president of a corporation having sales of more than twenty million dollars. I asked him who reported to the president. His reply was: "Everybody." When I asked what the effects of this condition were, his reply was substantially as follows:

"You can imagine the furore it creates. No one knows what his duties are since they are just what the 'old man' assigns that day; that creates confusion. No one can make any important decision until he checks with the 'old man,' and that slows us down a lot. Morale is poor and would be even worse if we did not love the 'old man.' The condition is easy to understand. He founded the business and until recent years, he could get into everything; now he can't. He is working himself to death. All this is just because he does not understand organization. We'd make a lot more money if he did."

It would be difficult to prepare a better exposition of the problem of organization than is to be found in this complaint against a chief executive who is regarded with affection by his entire personnel. The problem of organization is not concerned with theories, charts, and details—it deals with human emotions, ambitions, and personal effectiveness. The organization plan is the harness within which men work—or fail to work, if the harness is tangled.

Organization problems are extremely intangible. There is no physical evidence of them, such as exists when there is an unsatisfactory machine layout. They are not reflected directly in the figures because their effects cannot be isolated. Hence, it is easy to understand why many executives brush aside organization problems, which they feel are "theoretical," to deal with problems they consider more "practical." Yet what can be more practical than the development of a sound plan to govern the duties of the various individuals and to coordinate their efforts in carrying on the business?

Many executives who regard organization problems as "academic" also fail to appreciate that, whether they wish or not, they do have an organization plan. If the president knows it is not his responsibility to empty the waste baskets and the office boy does not try to direct sales, the reason is that there is an organization plan. The plan may have developed through trial and error and without conscious study on the part of anyone, but it exists nevertheless. The corporate executive must work in harness—tangled or otherwise.

Therefore, the question facing all executives (and particularly the chief executive) is whether the organization plan shall be examined to determine the advisability of changes, or whether any deficiencies shall be "adjusted for" through "give and take" rather than corrected. The organization plan *does* exist, and the question is, shall we try to improve it?

If a company is to try to improve its plan of administrative organization, the executive group (and particularly the chief executive) will first have to be convinced that organization problems are significant; next, that their solution is likely to produce worth-while results; and finally, that a practical working program for correcting organization deficiencies can be developed. My purpose is to deal with each of these topics from the viewpoint of the entire executive group and to point out what individual department heads and others can do to improve the organization structures of their own companies.

ORGANIZATION DEFICIENCIES, THEIR CONSEQUENCES

The experiences and mistakes of both successful and unsuccessful enterprises in matters of organization have resulted in the accumulation of knowledge into a body of organization principles. While these principles are not universally recognized, they are gaining increased acceptance; and it is well for anyone connected with an enterprise in an executive capacity to review, in the light of these principles, the plan under which the activities of his concern are administered.

(*a*) DELEGATION OF RESPONSIBILITY

A few years ago a company, the securities of which are listed on the New York Stock Exchange, was being administered by a president who had both great ability and a dominating personality. He was an exceedingly hard worker and he placed the success of his business above every other personal objective. He was conscious of the need for a sound plan of organization; in fact, the plan had been reduced to chart form. In practice, however, the senior executives reporting to the president had no real responsibility. Nevertheless, if sales were not satisfactory or manufacturing costs were too high, severe reprimands were in order for the executives concerned. The executives reported all details to him and took detailed instructions from him. Privately, the vice-presidents admitted that their actual status was that of clerks, and at least two of them were quietly seeking new connections.

The results of this condition were exceedingly serious. With improving business conditions the company's volume and profits fell behind those of the industry, and earnings were exceedingly disappointing. The president was completely at a loss to understand the situation: He felt the company's standing with the trade was good, he thought that its products were competitive, he knew its costs were low, and he was sure he was working harder than ever. What he did not appreciate was that while his executive group were telling him what he wanted to know, they were working without enthusiasm and were simply passing on to him a mass of detail which he could not digest and convert into sound decisions.

Dry rot had set in because the plan of organization violated two fundamental principles: First, that as the activities to be supervised become more numerous or more complex, responsibility for their supervision should be delegated to subordinates; and secondly, that an executive who is held responsible for the

Contributed by the Management Division for presentation at the Annual Meeting, New York, N. Y., Dec. 5–9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

supervision of activities must be given authority commensurate with the responsibility.

There is nothing obtuse in these principles. They are simply a common-sense expression of the limitations and motives of human beings. One man can perform only so much work effectively. If the amount becomes too great or there are too many different kinds of things to do, he must get help. If he does get help, however, anyone who assumes the rôle of an assistant has a natural desire to carry on this work on an independent basis. If he is a good executive, he will have pride and self reliance. He cannot work effectively or with enthusiasm if he does not have the standing and authority within the business to get the things done that have been assigned to him. Moreover, it is unfair to hold him responsible unless he is given the power to act.

These two principles are frequently violated. The consequences are several: Self-reliant executives are not developed; conflicting authorities result in slowness of action, friction, and personal bitterness; and operating expenses are increased. Many times violations of these principles are not recognized. Executives interested in attaining an efficient operation will be alert to detect an organization structure in conflict with them.

(*b*) CLASSIFICATION OF ACTIVITIES

If an executive wishes to delegate responsibilities and the authority required to carry them out, he must decide what combination of responsibilities he shall assign to any one individual. Economical operations, except in cases of extreme specialization, require that the executive shall supervise several activities. If these are not properly classified, the result is unnecessarily high costs, poor performance, or both.

An extreme case existed in a large retail coal business which was owned by four brothers. One of the brothers was responsible for industrial coal sales, taxes, insurance, and consumer credits. When I asked about this peculiar classification of duties, the president (one of the brothers) said, "Oh, we just try to keep the volume of work about evenly balanced among the four of us. The work of the treasurer got pretty heavy so we gave some of his work to the industrial sales manager."

While this is an unusual case, it illustrates the serious consequences which may result. In this case, tax problems received almost no executive attention and consumer credit losses were extremely high. On the other hand, industrial sales were being handled with a fair degree of effectiveness.

These serious consequences illustrate the third major organization principle; namely, that duties must be properly classified when they are grouped for purposes of delegation for supervision by one individual.

Again, this principle has its genesis in human limitations. Most people have a rather limited range of interests, abilities, and personality characteristics. The mathematical or engineering type of mind may not deal effectively with intangibles, and the introvert type of personality may find it distasteful to meet and deal with new people, as is required in selling. These things were true in the case of the coal executive. He liked the challenge of meeting people in industrial selling, while he found the credit and tax work tedious. He had time for supervision of all, but his range of interests and abilities caused him to neglect some of his duties and to do others poorly.

Thus, a "proper" classification is one which groups together the types of activities which will fall within the range of interests and abilities of one individual. Unfortunately, this range will usually be narrower than economical operations will permit to be recognized by specialization of effort. Thus, in developing the organization plan one must exercise judgment in striking a proper balance between higher costs resulting from overspecialization and higher costs resulting from inefficient supervision of too many activities.

(*c*) PROVIDING FOR ALL ESSENTIAL ACTIVITIES

As our businesses have grown in size and become more complex, an increasing number of activities have fallen to specialists to supervise Each executive in the larger enterprises has a relatively small number of activities under his supervision. This process of specialization has many advantages but it is not without its risks.

One of the principal risks is that the supervision of all activities will not be provided for. In a simple business where a few men do many things, they take responsibility for doing anything for which a need develops. In a company supervised by specialists, however, each executive has his own interests. Moreover, it is natural for him to assume that all tasks which are not his have been assigned to some other specialist. For these reasons, in a substantial proportion of our businesses there are tasks which are not being done because they have not been assigned specifically to any executive for supervision.

There is a large metal-specialty company which is headed by a chief executive who founded the business and expanded it to its present size. The success of the company during its early years was based largely upon this executive's ability to reduce costs. Through changes in design, manufacturing methods, and assemblies, he was able to undersell competitors. As the business grew, however, he found that the company's cost advantages grew smaller when he thought they should have increased. Through study of the problem it was discovered that the reason lay in inattention to cost reduction. He still gave it some attention, but he was so busy as an administrator that he could not devote much time to being an industrial engineer. He found that none of his subordinates had assumed specific responsibility for this specialized activity, although they all sought low costs in a general way. The solution was found in the establishment of an industrial-engineering department with responsibility for effecting reductions in cost and improvements in effectiveness.

Any executive interested in improving the operation of his business will seek to determine whether there are important activities for which no provision for supervision has been made. The following are some of the activities which are most frequently overlooked but for which most well-managed medium and large-sized corporations will provide.

1 Sales and Market Research. When businesses were small, the senior executives had opportunities to meet customers and know their habits and wants. This is impossible on any extensive personal basis for a concern of even moderate size, and provision for securing the information on a more formal basis must be made. This department, which may consist of only one man or just the part-time efforts of one, should be responsible for sales analysis and market research.

There is some disagreement among students of organization whether research shall be centralized in one department or decentralized in the departments to which it pertains. Those in favor of centralization point out the need for consideration of the work of several departments and the greater likelihood of enforcement of results if the research executive reports directly to the chief executive. Those in favor of decentralization emphasize the greater knowledge of details which those engaged in decentralized research will have and the more effective use of the results which will be made if the research is done in the division to which it pertains.

Both schools of thought are correct "on principle" and the only divergence comes in determining which plan is best as a practical matter. No general decision on this question would

be sound, and conditions in individual situations will be controlling. However, present-day business conditions require increasing emphasis upon the research viewpoint, and I believe this viewpoint can be generally developed in the executive group most quickly if research is decentralized. If this decision is made in the case of sales research, the supervisor of this activity will report to the executive in charge of sales.

2 *Personnel Management.* Recognition of the need for proper supervision of this activity is spreading rapidly. Companies which have provided for it have had less trouble with labor, but employee relations is only one of the many responsibilities of a properly organized personnel department. Some of the others are selection, training, promotion, health and safety, and discharge of employees, and their protection against unemployment, death, old age, and disability. Wage and salary administration, measurement of employee attitudes, and collective bargaining are also responsibilities of the personnel executive.

Probably the majority of businesses today need to give more attention to their administration of personnel activities. While it will not be true universally, in many businesses the personnel function is of sufficient importance to justify its supervision by a major executive reporting to the president. In all companies this function should be supervised by some one other than the factory employment manager. The personnel executive should have only functional authority over executives and employees, other than those in his own department, and the major responsibilities in personnel matters must be discharged by the line organization.

3 *Industrial Engineering and Manufacturing Methods Research.* These activities should be specifically provided for. In the smaller businesses there may not be the need for the full time of an employee, but in larger concerns the possibilities for improvement may justify several specialists in this field.

If the decision made in the case of sales research is followed, the supervisor of these activities will report to the executive in charge of manufacturing.

4 *Expense Analysis.* This important activity is frequently not specially provided for. Of course, all executives are responsible for keeping the expenses of their departments at a minimum, but with the extreme degree of specialization required in business today this general responsibility is ordinarily not adequate. The specific responsibility should usually be placed upon the controller. He has most ready access to the figures; and to a greater extent than other executives, he can view department operations objectively and from an over-all company profit standpoint. In the modern conception of the controller's duties, analysis of expenses is one of his most important responsibilities. This responsibility is confined to pointing out the need for expense reduction to the line executives and to cooperating with them in determining the various possibilities for improvement. The responsibility for effecting the expense reduction rests with the executives in charge of the particular activity.

5 *Budgetary Control.* This activity has been given increased recognition during the past two decades. The need for its recognition, which was first brought home in the early twenties,[1] is now quite commonly accepted. There are still many companies, however, which do not make adequate provision in their organization plans to insure that the maximum value is obtained from their budget procedure.

The chief executive is, of course, the chief budget officer, just as he is the chief personnel executive, and each line executive should make the estimates upon which the budget for his department is based. Responsibility for the assembly of budget data, however, should be delegated specifically to one executive. In smaller concerns this will fall to the controller; in larger concerns to a budget director reporting to the controller.

6 *Clerical Methods Research.* In large concerns this responsibility is of sufficient importance to justify the employment of an individual for full time. In smaller concerns the controller will have to assume this responsibility and delegate special tasks to the various subordinates in the department.

This activity consists of special studies to eliminate needless clerical detail and "paper work," to simplify essential clerical procedures, and to seek constantly to effect reductions in clerical expense. One large corporation recently saved nearly a quarter of a million dollars through special studies of this character. It now has a special department of several individuals who devote themselves exclusively to scraping off the clerical barnacles which inevitably accumulate.

(*d*) SPAN OF CONTROL

As the activities to be supervised become more numerous or complex and the number of subordinate executives increases, a saturation point is reached in the process of delegating responsibility to increase the effectiveness of supervision. The efforts of subordinates must be coordinated; otherwise they will work at cross-purposes, or fail to act at all, and thus nullify the advantages gained through specialization.

The fifth major principle of organization, therefore, is that an executive shall have only a limited number of executives reporting to him. We saw the effects of the violation of this principle in our first case, where the vice-president said that "everybody" reported to the president. The inability of the president to coordinate the activities of the various department heads led to slowness of action, high costs, and poor morale.

Again, this principle is founded upon time and human limitations. Subordinate executives should work in harmony to carry out the company program. This can be accomplished only through the common superior's devoting the necessary time to discussions with subordinates to gain an understanding of their problems, to impart to them an understanding of the problems of the other department heads, and to give them instructions in the execution of a unified company program. Obviously, as the number of subordinates increases or the problems become more complex, the limitations of time require that the number of subordinate executives be limited.

The question of the "proper" number of subordinates cannot be answered categorically. Obviously, the number of individuals whose efforts can be coordinated by one man will depend upon what is to be coordinated and the ability of the coordinator. There are several tests which may be applied in reaching a decision upon this question. First, the greater the similarity of duties among the various subordinates, the larger the number of subordinates the superior can coordinate effectively. Secondly, when the duties of the subordinates are of a routine character, and therefore their demands upon the time of the superior are less, the larger will be the number of subordinates the superior can coordinate effectively. Thirdly, the more self-reliant the subordinates become and the greater the capacity of the superior, the more subordinates he can supervise effectively. Fourthly, as the level of supervision steps down from the central control of the chief executive, the easier it is to effect coordination and the greater the number which can be supervised effectively by a common superior; this results because the more important the position of the executive, the more time he should have for planning and the less time he should be required to devote to the details of administration.

Without seeking to answer the question categorically, it

[1] See "Budgetary Control," by J. O. McKinsey, Ronald Press, 1922.

may be said that whenever the number of subordinates reporting to any executive exceeds seven, the organization plan should be examined to determine that there are sound reasons for the larger number. If the number of executives reporting to the chief executive exceeds five or six, it will usually be found that the chief executive does not have sufficient time for the development of major policies and long-term plans; and under these conditions the company is likely to suffer a gradual loss of competitive position with a consequent decline in earnings.

(e) PROVISION FOR COORDINATION

Since the organization plan is the means for harnessing human energy, provision must be made to insure that all those in harness are pulling together. While limiting the number of subordinates will permit their coordination, positive means to achieve this objective should, if possible, be provided for in the organization structure.

The textile industry provides numerous illustrations of deficiencies in coordination. Owing to emphasis upon low unit costs, long runs are common, and frequently inadequate attention is given to style changes and to market demands for particular items in the line. This lack of coordination between selling and manufacturing results in serious markdowns which more than offset low unit costs.

A number of companies in the textile, packing, and shoe industries have provided for coordination by the establishment of a department for this purpose which gives consideration to style influences, and to manufacturing and distribution costs in reaching decisions which will result in the greatest net profit for the business. This plan is worthy of consideration by any company with a large number of items in the line which must be changed annually or semi-annually because of style or design factors.

In large businesses coordination can be improved through the establishment of committees which meet to discuss problems involving several departments. It is essential, however, that committee action does not replace decision making by the line executive or is not used as a "buck-passing" medium.

For the most part, however, coordination cannot be predicated upon the organization structure itself. Unless the business is of great size, coordination among the major functions of the business (such as sales, manufacturing, personnel, finance, and control) must be effected through the efforts of the chief executive. In fact, his two principal functions are planning and effecting coordination. If the organization plan is soundly conceived and he has the proper qualifications of leadership, he can adjust the harness, offer the encouragement, and apply the whip in such a manner as to effect the "pulling together" which is so essential for profitable operations.

The major executives reporting to the chief executive can, in turn, effect coordination within their divisions by means of personal contact with their subordinates. Thus, securing coordination in a soundly organized business becomes largely a matter of the effectiveness of executive personnel. Coordination is the dynamic aspect of organization and cannot be secured through planning alone.

The budget should be employed as an aid to coordination. Proper budgetary procedure will require cooperative effort in expressing future plans in terms of projected financial results. Corporate action must be thought through before a true budget can be developed. Thereafter, that action which is then understood by the entire executive group can be carried out more readily. Many companies fail to obtain the full benefits from budgeting because the budget program has not been developed in a manner to secure maximum coordination.

Discussion of coordination would not be complete without pointing out that harmony in the executive group does not necessarily signify that it is properly organized. Many times the effectiveness of personnel is such that organization deficiencies are covered up by personal adjustments and understanding among broad-gaged individuals which tend to offset the adverse effects of improper classifications of activities, limitations of authority, failure to delegate responsibility, and the like. It cannot be overemphasized that in these same companies administration would be improved materially, and profits increased accordingly, if organization deficiencies were eliminated. With the need for personal adjustments to offset organization deficiencies eliminated, the enthusiasm of individuals should increase substantially.

Mention should also be made of the "happy corporate family." Many otherwise able chief executives permit organization deficiencies to exist as long as they think the executive group is "just a happy family" and that organization problems do not require attention because the executives "all work together." In the first place, if the men down the line talked frankly, the chief executive would frequently find his family was not so happy. Secondly, the happiness—and more important the effectiveness—of the corporate family would be increased materially if the organization deficiencies were corrected and the broadminded attitude of the personnel was put to better use than avoiding friction.

It is fundamental that maximum effectiveness cannot be secured if coordination techniques are used as wire to mend a faulty corporate harness. The corporate team would pull a greater load with a sound harness.

(f) LINE AND FUNCTIONAL AUTHORITY

Sound organization requires that each executive understand whether his authority is of a line or functional character and govern his actions accordingly. Understanding of the difference between these types of authority is increasing.

Line and functional authority have been defined in various ways. The executive with line authority says "do," the executive with functional authority says "if and when you do, do it this way." The line executive determines the need, time, and place for action, while the executive with functional authority defines the method. Unless each executive recognizes the nature of his authority and governs himself accordingly, conflicts will arise.

In the case of an automotive-parts company the controller found that the inventory of one of the branch sales offices was unduly high in certain types of items. He issued instructions directly to the executive in charge of the office to reduce his inventory and to sell at reduced prices if necessary. The sales manager learned of it later when price cuts had been made and was furious because he had plans for moving the inventory at the full price. The controller, whose authority over any department other than his own is always functional, had exercised line authority over the branch sales executive.

The difficulties in failing to recognize the difference between these types of authority usually arise because the executives with functional authority seek to exercise line authority over the employees of the other divisions. If this is permitted, the making of prompt decisions is difficult, since they must be approved in two divisions rather than one.

Maintenance of the distinction between line and functional authority is simply an expression of the universal desire that a man should have only one "boss." If he has more than one, he is likely to receive conflicting instructions, will certainly be confused, and is divided in his loyalties. If the authority of the "boss" is exercised only by the line organization, there will be none of these conflicts.

(g) SUMMARY OF PRINCIPLES

The major organization principles, violation of which results in loss of effectiveness and high costs, may be summarized as:

1 As activities to be supervised become more numerous or complex, responsibility for their supervision should be delegated to subordinates.

2 An executive should be given sufficient authority so that he may discharge satisfactorily the responsibility which has been delegated to him. This principle is sometimes stated, "responsibility and authority should go hand in hand."

3 When grouping activities for delegation of supervision to subordinates, an executive should classify them so as to permit maximum efficiency in supervision by one individual.

4 The plan of organization should provide for the supervision of all essential activities.

5 One superior should not have more subordinates than he can coordinate effectively.

6 Adequate provision should be made for the coordination of related activities so as to insure that common objectives will be attained.

7 The distinction between line and functional authority should be recognized.

CORRECTING ORGANIZATION DEFICIENCIES

If the foregoing case material has been persuasive that a tangled corporate harness does have an adverse effect upon net profits, the next consideration is what an individual executive may do about it in his own business.

(a) DETERMINING WHETHER DEFICIENCIES EXIST

The first step, of course, is to determine whether deficiencies do exist. The individual executive should review, in the light of the principles stated, the activities which are under his direction, and then those of other departments which affect the functioning of his.

If he finds that defects exist in his own department, he can correct them without difficulty, but if he finds that defects exist in other departments he is not in position to act. Under these conditions he should request the chief executive to undertake a study of the company's organization structure, pointing out the difficulties as he sees them for study by the chief executive.

The chief executive is the only one in a position to undertake a thorough study of organization, since he is the only one who will not be affected personally by changes in duties. He, however, can probably not devote the time to make a study. He should, therefore, assign this task to his personal assistant; or, if he does not have one, appoint one for this purpose.

The vicious thing about organization deficiencies is that they are like "halitosis"—they may exist without the chief executive's knowing it. Even his best friend in the company won't tell him since it may imply criticism of the chief executive himself or adversely affect the personal position of that friend in the business. For this reason, the responsibility for discovery of organization defects rests primarily with the chief executive himself, although it will be an act of real friendship for his subordinates at least to whisper to him about their existence so that he can do something about them.

(b) CLARIFYING THE ORGANIZATION STRUCTURE

It is fundamental that operating efficiency is increased if a man knows what his duties are, who his boss is, and what his authority includes. He can work more quickly, more certainly, and more enthusiastically. Conflicts will be avoided which lead to personal jealousies, and the playing of politics to increase authority will be a less profitable avocation.

A program to increase such understanding should include:

1 Preparation of an organization chart.

2 Preparation of an organization manual.

This program will not only increase understanding but will also help to disclose organization deficiencies and to promote revisions in accordance with sound organization principles.

The program should be under the direction of the special assistant to the chief executive. It should be emphasized that even if the chart and manual are thrown away after they have been prepared, the increased understanding which will be brought about by their preparation will be ample repayment for the time spent.

An organization chart is a well-recognized tool of management, although some executives are inclined to consider it a somewhat unnecessary tool. The organization manual is less widely employed. It is interesting to note, however, the high degree of correlation between profitable operations and the use of such tools.

The organization manual consists simply of a written statement of the duties and responsibilities of the various executives. Industry has borrowed the idea from the army where failure to understand organization may mean the difference between life and death. There is nothing complicated about an industrial organization manual, but it is significant that many executives have trouble in preparing the simple list of their duties to be included in it.

The preparation of an organization chart and manual will accomplish the following for any company:

1 Each executive will be required to think through what he believes his duties should be.

2 Any questions as to whether a particular duty shall be supervised by one executive or another will be settled and agreed to by both.

3 Each executive will obtain an understanding of his own responsibilities and authorities, as well as those of every other executive.

4 Complete agreement will be obtained among the executive group as to how responsibilities shall be divided.

5 Any defects in organization will be disclosed during the process of preparing the organization chart and manual.

6 Buck passing will be made more difficult and the giving of credit and placing of blame more easy.

Definite techniques for the preparation of the chart and manual have been developed through experience, but space will not permit dealing with them in this article. It may be said, however, that these techniques are designed to increase understanding with the actual chart and manual as secondary objectives. Essentially, the procedure is built around a series of meetings among superiors and subordinates at which the organization decisions are discussed and made.

The rewards for a proper adjustment of the corporate harness are many. The principal one, of course, is increased operating effectiveness resulting in greater net profits. There are several by-products, however. Personal animosities are less numerous; corporate politics—the great curse of business—has less fertile ground in which to grow; enthusiasm increases; and the happy, and effective, corporate family can become an actuality.

I appreciate, of course, that many executives will simply dismiss these possibilities as "lovely but impractical thoughts" and be quite content to jog along in a tangled corporate harness. In the meantime, however, the progressive and profit-conscious executive, who is already enjoying the benefits of a sound organization structure, is well ahead in the competitive race which becomes increasingly keen with each passing year.

Progress in RAILWAY MECHANICAL ENGINEERING, 1937–1938

Construction Slowed Down, but Previous Equipment Orders Completed

A RECESSION year covered by this report, September, 1937, to September, 1938, has witnessed the slowing down of construction, but the completion of notable equipment orders previously placed. New locomotives for passenger service continue in increasing numbers to be streamlined or at least "styled." The simple articulated type retains its popularity for the heaviest service. The installation of complete new trains continues, using either Diesel-electric or steam power and the current trend in passenger equipment uses alloy-steel or aluminum-alloy weight-reducing construction, streamlining, partial articulation, and high-efficiency brake gear. A new maximum in power of Diesel-electric units has been attained, and construction of locomotives of high power to meet passenger requirements continues. The Diesel-electric switcher is built in increasing numbers; construction of steam switching power has nearly ceased. Passenger-train equipment, in decoration and furnishing, maintains and advances standards set in recent years. Freight-car construction conforms more and more to the standards of the Association of American Railroads (A.A.R.) and there is continued effort toward weight reduction in order to decrease tare and to increase net capacity within prescribed rail loads.

The most striking development abroad is the continual expansion of the internal-combustion engine, especially as evidenced by the large number of Diesel-mechanical power units and special trailers. These are generally of the extreme light-construction type, with liberal use of articulation.

GENERAL NOTES

As compared with the year before, the period is not a very active one. The increased business activity felt late in 1936 was well spent and decided retardation had set in by the beginning of the period covered by the present report. While the latter part of 1937 included the completion of several noteworthy equipment projects, few new orders were placed, and the same situation extended through the third quarter of 1938. The railways have been so pressed economically that spending for experiment and development has been limited, though the equipment builders have continued existing programs.

The following general matters call for brief mention:

1 The disbanding of the Research Division of the A.A.R. under the directorship of L. W. Wallace, and the establishment of the position of mechanical engineer for Division V.

2 The Interstate Commerce Commission stoker order of December, 1937. This requires that mechanical stokers be installed on all coal-fired passenger locomotives with 160,000 lb or more on the drivers, and on freight locomotives with 183,000 lb or more built in the future, and that 20 per cent of those in service be so equipped by July 1, 1938, and an additional 20 per cent during each following year. The date was later postponed to October 1st.

3 Postponement of enforcement of the A.A.R. ruling on arch-bar trucks. The present ruling is that no arch-bar trucks will be received in interchange from owning roads after January 1, 1939. This date has already been set ahead several times.

4 The organization of the Committee on Further Development of the Reciprocating Steam Locomotive of Division V late in 1937. The 1938 report of the Committee was that the problem before it had been rendered more concrete by the attempt to learn the necessary elements of the design of a locomotive capable of pulling a trailing load of 1000 tons at 100 mph. The following dimensions and characteristics have been tentatively adopted:

Indicated horsepower, 6400; drawbar horsepower, 4000.

Four-cylinder nonarticulated engine, with driving axles coupled in two pairs, 84-in. driving wheels preferred.

Conventional boiler, radial-stay type if possible, able to supply 100 per cent of the cylinder demand plus steam for the auxiliaries, to deliver steam at 300 lb and 750 F, and to burn 12,000-Btu bituminous coal.

Provision to be made in the design for streamlining; antifriction bearings to be used throughout.

The factor of adhesion to be 4.5 if possible, and the engine to traverse 18-deg curves.

5 Reports of other Division V committees having items of engineering interest include those from the Locomotive Construction Committee, which says on the subject of high steam pressures: Full advantage of higher boiler pressure cannot be secured unless means are found of operating at a decreased cutoff and increased expansion ratio; "some progress is being made in this direction by the use of double-ported valves, also the poppet valve, though much remains to be accomplished with the latter."

On the subject of oil-engined locomotives, the following information is of interest: There are 436 Diesel-electric locomotives in service or on order as of March 1, 1938; these include 2 of 5400 hp, 6 of 3600 hp, 2 of 3000 hp, and 4 of 2400 hp, all built for passenger service.

With regard to roller-bearing service the following data are presented:

	Number of engines equipped	Maximum mileage without failure	Minimum miles per failure
Engine trucks	689	736000	174000
Driving journals	280	347000	301000
Trailing trucks	149	367000	263000
Tender journals	578	682000	169000

Cooperation between the car-design committee of the mechanical division of the A.A.R. and the design committee of the American Railway Car Institute, in the economic study and

Report prepared by the Railroad Division, Committee RR6, Survey, Prof. E. G. Young, Chairman, for presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, N. Y., December 5–9, 1938.

TABLE 1 DOMESTIC STEAM LOCOMOTIVES

Item No.	Owning Road	Builder	Type	Weight in 1000's			Cylinders		Evaporating Sfce	Superht'g Sfce	Tube Length Ft.-In.	Working Pressure	Diameter of Drivers	Grate Area	Tractive Force
				Total (Eng.)	Drivers	Tender	No.	Size							
1	Canadian Pacific	ALCo	4-4-4	241	110	185	2	16½×26	2291	900	15-11	300	75	45.0	24,000 *†
2	New York Central	ALCo	4-6-4	365	202	316	2	22½×29	4187	1745	19-0	275	79	82.0	43,400 *†
3	Delaware Lack'a & W'n	ALCo	4-6-4	371	198	313	2	26×30	3854	1123	17-6	245	80	81.5	52,800
4	Chi. & North Western	ALCo	4-6-4	412	216	360	2	25×29	3979	1884	19-0	300	84	90.7	55,000 †
5	Atchison, Topeka & S.F.	BLW	4-6-4	412	213	396	2	23½×29½	4770	2080	21-0	300	84	98.5	49,300 †
6	Soo Line	Lima	4-8-4	446	263	318	2	26×32	5142	2120	21-6	270	75	88.3	66,000
7	Atlantic Coast Line	BLW	4-8-4	460	263	436	2	27×30	4749	1497	21-0	275	80	97.8	63,000
8	Southern Pacific	Lima	4-8-4	460	267	373	2	26×32	4887	2086	21-6	280	80	90.4	62,800 *†
9	Union Pacific	ALCo	4-8-4	465	270	367	2	24½×32	4597	1473	20-6	300	77	100.0	63,600
10	Denver & R.G. Western	BLW	4-8-4	479	279	394	2	26×30	5506	2336	21-0	285	73	106.0	67,000
11	Chi., Milwaukee, St.P. & P.	BLW	4-8-4	490	282	397	2	26×32	5509	2336	21-0	285	74	106.0	70,800
12	Northern Pacific	BLW	4-8-4	492	294	386	2	28×31	4766	2026	19-6	260	77	115.0	69,800
13	Atchison, Topeka & S.F.	BLW	4-8-4	500	287	396	2	28×32	5403	2366	21-0	300	80	108.0	66,000
14	Bangor & Aroostook	ALCo	2-8-0	239	198	162	2	22¼×30	2636	426	14-9	225	63	50.8	45,100
15	Pere Marquette	Lima	2-8-4	446	278	358	2	26×34	4785	1932	19-0	245	69	90.3	69,400*
16	Kansas City Southern	Lima	2-10-4	514	353	360	2	27×34	5154	2075	21-0	310	70	107.0	93,300
17	Bessemer & Lake Erie	ALCo	2-10-4	520	369	377	2	31×32	5900	2396	21-6	250	64	107.0	97,300*
18	Atchison Topeka & S.F.	BLW	2-10-4	545	372	360	2	30×34	6075	2675	21-0	310	69	121.5	93,000
19	Seaboard Air Line	BLW	2-6-6-4	480	330	314	4	22×30	5429	2397	24-0	230	69	96.3	82,300
20	Norfolk & Western	Ry	2-6-6-4	·	·	·	4	24×30	6650	2703	24-1	275	70	122.0	104,500
21	Union Pacific	ALCo	4-6-6-4	582	403	312	4	22×32	5381	1650	22-0	255	69	108.0	97,400
22	Spokane, Port. & Seattle	ALCo	4-6-6-4	621	436	394	4	23×32	5832	2114	23-0	250	69	152.0	104,500
23	Denver & R.G. Western	BLW	4-6-6-4	642	438	394	4	23×32	6341	2628	22'-0	255	70	136.5	105,500
24	Norfolk & Western	Ry.	2-8-8-2	583	523	380	4	25/39×32	5656	1775	24-1	300	57	106.0	126,800 *
25	Western Pacific	BLW	2-8-8-2	663	550	404	4	26×32	6811	2152	23-0	235	63	145.0	137,000*

* Equipped with booster which adds about 12000 lb. to tractive force. † All or part of engines on this order streamlined.

design of standard cars and the development of lightweight designs, continues; more than seven eighths of the house and hopper cars ordered during the reporting year were of standardized design throughout or conformed closely to the standard designs. Forty- and fifty-ton automobile cars, standard refrigerators, and further study of hopper cars are on the program for future work.

6 There have been some notable publications during the year:

Andre Chapelon of the former Paris-Orléans-Midi organization, famous for his scientific locomotive modernization, has published a voluminous and profusely illustrated work.[1] It reviews everything in current locomotive practice and provides sections on the dynamics and thermodynamics of the locomotive, various methods of testing, and an important chapter on projected designs which differ radically from current practice.

The Central-European Railway Management Association (Eisenbahnverwaltung) has published volume 2 of its series dealing with locomotives in continental Europe (particularly in Germany) from 1880 to 1920.[2] The book presents a pageant of success, and failure as well, in the work of the geniuses von Borries, Hammel, Sanzin, Garbe, and many others.

The Baldwin Locomotive Works has given limited distribution to a series of papers in planograph form under the general title "The Motive Power Situation of American Railroads," with sections on "Locomotive Demand," "Equipment Investment Policy," "Cost of Locomotive Operation and Maintenance," "Economic Life," and others. The importance of the studies is scarcely indicated by the modest appearance of the brochure.

7 The annual statistical number of *Railway Age* of January 1, 1938, presented the following information of special interest to the mechanical engineer:

Orders for locomotives and cars	1937	1936	1935	1934
Locomotives, all classes	425	534	114	183
Freight cars	60035	67815	21120	24623
Passenger cars	928	317	107	388

Orders reported up to July 1, 1938 (from later numbers) are: steam locomotives, 54; other locomotives, 29; passenger-train cars, 96; freight cars, 14,050. These figures are subject to correction. The orders for the first half of the year were about one quarter of those for the corresponding 1937 months. The equipment installed and on order for the first half of recent years is as follows:

Installed	1938	1937	1936
Steam locomotives	132	166	18
Other locomotives	72	20	11
Freight cars	6260	34187	11604
On order			
Steam locomotives	37	301	67
Other locomotives	26	33	23
Freight cars	5021	42624	28089

8 Two notable mileage records have been reported in the

[1] "The Steam Locomotive," by Andre Chapelon, J.-B. Balliere et Fils, Paris, France, 1938.

[2] "The Development of the Locomotive," vol. 2, 1938. R. Oldenbourg, Berlin. Vol. 1 of this series was published in 1930 and covered the period from 1835 to 1880.

TABLE 2 FOREIGN STEAM LOCOMOTIVES

Item Number	Railway	Type	Builder	Weight in 1000's			Cylinders			Working Pr.	Driver Diam.	Evaporating Surface	Superheating Surface	Grate Area	Tractive Force	Service
				Total Engine	On Drivers	Tender	Number	Simple or Compound	Size							
1	London Midland & Scottish "Coronation" Class	4-6-2	Ry.	252	150	·	4	S	16¼×28	250	81	2807	856	50.0	40,000	Passenger
2	London & North Eastern "Coronation" Class	4-6-2	Ry.	230	148	144	3	S	18½×26	250	80	2576	749	41.3	35,500	Passenger
3	L. & N.E. Rebuilt "10,000"	4-6-4	Ry.	231	147	143	3	S	20×26	250	80	2598	749	50.0	41,400	Passenger
4	L. & N.E.	2-6-2	Ry.	208	147	116	3	S	18½×26	220	74	2431	722	41.2	33,700	Pass. or Frt.
5	Reichsbahn (Germany)	2-8-2	B.M.A.G.	229	157	168	2	S	20.5×28.4	285	63	2269	754	44.0	44,000	Freight
6	Alsasce-Lorraine	2-10-2	Various	297	220	115	3	S	22.6×28.4	227	60	2640	1092	53.8	47,000	Freight
7	Paris-Orleans-Midi	4-6-2	Various	225	106	·	4	C	16.5×25.6 25.6×27.2	227	76.1	2270	860	45.9		Passenger
8	Bergen-Oslo (Norway)	2-8-4	Thunes	221	140	119	4	C	18.2×25.6 28.6×27.6	240	60	2742	1092	55.6		Pass. & Frt.
9	U.S.S.R. State Rys.	2-8-4	Various	294	181	-	2	S	26.4×30.3	221	72.3	3175	1597	75.3	34,000	Passenger
10	U.S.S.R. State Rys.	2-10-4	Various	294	222	-	2	S	26.4×30.3	221	59.1	3175	1597	75.3	42,000	Freight
11	Turkish State Rys.	2-8-2	Hensch.	230	160	138	2	S	25.6×26	228	68.9	2401	1138	43.0	32,000	Passenger
12	Turkish State Rys.	2-10-0	Hensch.	232	200	138	2	S	25.6×26	228	57.1	2401	1138	43.0	40,000	Freight
13	Bengal-Nagpur (India)	4-6-0	Stephenson-Hawthine	168	113	142	2	S	21½×26	200	73½	1600	317	38.0	27,300	Passenger
14	Rhodesian Rys.	282-282 Garratt	Stephenson-Haw.	337	240	—	4	S	18½×24	180	48	2388	480	49.5	52,400	Freight
15	South African Rys.	2-10-4	N.B.L.Co	237	182	145	2	S	24×26	210	54	3414	661	62.5	43680	Freight
16	Reichsbahn	4-6-2	Borsig	220	117	153	2	S	23.6×26	228	78.8	2368	753	44.0	35500	Passenger

All dimensions reduced to English units.

technical press, both of which were obtained with the engines in assigned passenger service: Chicago, Milwaukee, St. Paul & Pacific 4-8-4 locomotive No. 222 ran 19,282 miles in March; Seaboard Air Line 4-8-2 locomotive No. 249 ran 20,049 miles in January.

9 The highest speed, with fully substantiated timing, is reported: The London and North Eastern Pacific-type *Mallard*, with 80-in. drivers, maintained a speed of 120 mph for 5 min, and attained a maximum of 125 mph. The previous record of 120 mph, held by a Reichsbahn Pacific with 90-in. drivers, is claimed by the British writer not to have been timed in a way to give certainty to the results.

STEAM LOCOMOTIVES, CONVENTIONAL TYPES, OF THE YEAR

Table 1 gives the principal dimensions of 25 classes of locomotives constructed in the United States and Canada during the latter half of 1937 and in 1938 to the date of this report. Not all such are included, but the list shows the locomotives built on the larger orders, and several others of special interest. Items 2, 5, 6, 7, 23, and 24 are illustrated in Figs. 1 to 6 inclusive. From the table the popularity of the 4-6-6-4 type is evident. The construction of a new Mallet compound (item 25) is unusual. A few fully modern small engines are being built for domestic requirements (items 1 and 14). The Santa Fe 2-10-4 (item 18) has the heaviest published weight per driving axle, the greatest piston thrust, and is the heaviest nonarticulated engine yet reported. The Atlantic Coast Line 4-8-4 (item 7) is of note because of the use of the 16-wheel tender.

REPRESENTATIVE FOREIGN LOCOMOTIVES

Table 2 summarizes the principal dimensions of a group of recently built foreign locomotives. Items 1, 3, 9, and 14 are illustrated in Figs. 7 to 10 inclusive. Items 1 to 4 represent current British practice; the first and second are direct outgrowths of the *Coronation* locomotives described last year and the third, as shown in Fig. 8, a reconstruction of the No. 10,000 in which the water-tube boiler first applied has been replaced by one of the conventional type. Item 4 is a compromise freight-passenger type, capable of meeting all but the most severe requirements in either service. Item 5 is a new Mikado locomotive for fast freight service on the Reichsbahn. Items 6 and 7 are two types which will apparently become standard with the newly amalgamated French railway system. The latter is the Chapelon Pacific with steam-consumption records below 12 lb per ihp-hr. The particular interest of item 8 lies in the extensive use of welding throughout the construction. Items 9 and 10 are two locomotives which have been standardized by the Soviet railway system and are now under production in considerable numbers. There is also a 4-6-4 type which, operating with a condensing tender, has given excellent results on long runs in poor-water territory. Items 11 and 12 represent further standardization on the Turkish State Railways, while Nos. 13 and 14 are typical British-colonial construction. The Garratt type, with the boiler carried on a girder frame between two sets of running gear, and with fuel and water tanks carried directly on the running gear, seems to be a highly satisfactory solution to the problem of high capacity combined with low permissible rail loads, especially on narrow-gage lines.

LOCOMOTIVE STRUCTURAL FEATURES

Four important developments for the year should be noted.

The cast-steel locomotive bed has attained new dimensions exceeding all limits earlier imposed, but a rival construction is making some headway; the locomotive frame is profiled from a slab of rolled steel by the flame-cutting process.

The French railways have developed a satisfactory all-welded cylinder both for replacement and for new construction.

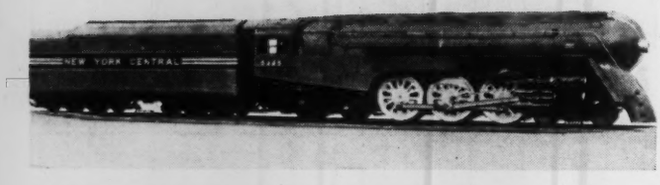


FIG. 1 STREAMLINED LOCOMOTIVE, ITEM 2 IN TABLE 1

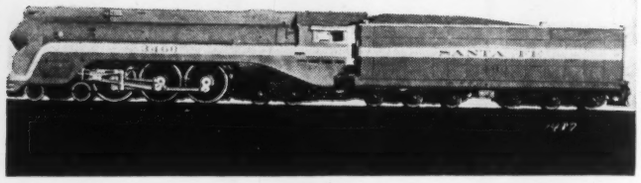


FIG. 2 STREAMLINED LOCOMOTIVE, ITEM 5 IN TABLE 1

FIG. 3 SOO LINE LOCOMOTIVE, ITEM 6 IN TABLE 1

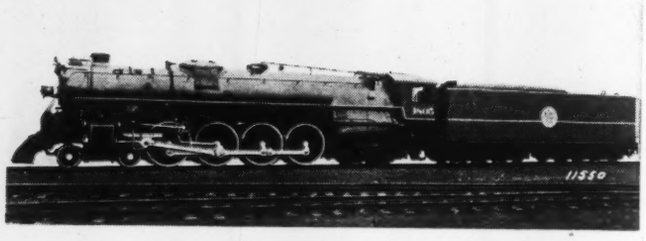


FIG. 4 LOCOMOTIVE WITH 16-WHEEL TENDER, ITEM 7 IN TABLE 1

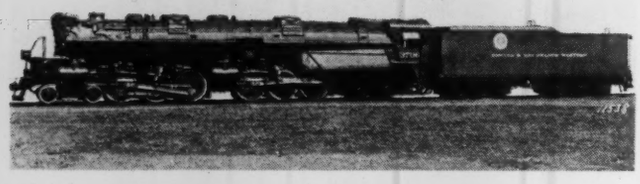


FIG. 5 SIMPLE ARTICULATED LOCOMOTIVE, ITEM 23 IN TABLE 1

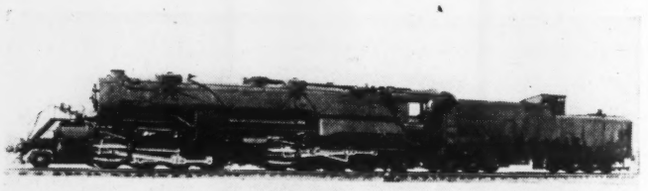


FIG. 6 MALLET LOCOMOTIVE BUILT BY THE NORFOLK & WESTERN, ITEM 24 IN TABLE 1

The process involves building up three partial assemblies: saddle, cylinder with ports and passages, and steam chest with ports and passages; and the erection of the partial assemblies for final welding in a hardwood jig. The result is a cylinder said to be intermediate in cost and weight between cast-steel and cast-iron cylinders with which it interchanges.

The double-disk driving-wheel center has been adopted for all new heavy power constructed in this country during the last year; it may be noted that many of the wheel castings simulate in appearance the spoked wheel which they replace.

The development and operation of machines for fatigue testing of full-sized axles lead toward the solution of design problems in which theoretical treatment has never been satisfactory. In the paper reporting this work[3] the superiority of axles with rolled-surface finish, when worked to service stresses, was clearly shown.

STEAM LOCOMOTIVES OF NONCONVENTIONAL TYPES

In this section the turbine locomotive and also what may be called the steam-motor type will be considered.

The committee reports prepared by L. P. Michael for the Railway Fuel and Traveling Engineers Association furnish from year to year the most complete notes and bibliography on this subject. The report to the 1937 meeting proposes a design of a 4000-hp turbomechanical locomotive of the 2-4-2 + 2-4-2 type. Steam is supplied by four continuous-tube radial-burner oil-fired evaporators, at 1200 lb and 850 F, with fully automatic control of fuel supply and air blast. The main turbines use 35,000 lb of steam per hr at full capacity. The entire top of the cab structure is an aluminum or copper-fin-tube condenser, cooled by eight 9-ft propeller fans taking air through side louvers and forcing it vertically through the tube bank. All of the fans are driven through bevel gears by a line shaft, which in turn is driven through bevel gearing by a small high-speed turbine and reduction gear. The main turbine consists of two 24-in. mean diameter Curtis wheels, and 18 reaction

TABLE 3

	5400-hp 3-unit Diesel-electric locomotive	5000-hp 2-unit turbo-electric locomotive	4500-hp conventional steam locomotive 4-6-4 type	4000-hp turbo-mechanical locomotive
Estimated cost	$625000	$650000	$150000	$360000
Total weight, lb	1008000	1060000	775000	500000
Weight per rated hp, lb	187	201	173	125
Tractive force				
At starting	160000	160000	55200	64000
At 60 mph	19000	19000	21000	19000
At 80 mph	10700	10700	13000	13700
Fuel used, lb per hp-hr, (oil)	0.9	1.4	2.9[a]	1.0
Cost per gallon, cents	5.5	3.5	3.5	5.0
Cost of fuel per hp-hr, cents	0.066	0.066	0.132	0.066

[a] Figures for steam locomotive added by present compiler.

[3] "Locomotive Axle Testing," by T. V. Buckwalter, O. J. Horger, and W. C. Sanders, Trans. A.S.M.E., vol. 60, May, 1938, paper RR-60-2, pp. 335–345.

stages, operating at 8000 rpm corresponding to a locomotive speed of 120 mph. At each end of the turbine are placed reduction gears which drive the output shafts at a corresponding speed of 2160 rpm; these shafts drive planetary transmissions through hydraulic couplings. Extending both ways from the transmission boxes, drive shafts continue to the driving axles on each end where power is transmitted to the axles through a differential reversing gear. The main girder frame and also each truck frame is a unit casting. The starting tractive force is 64,000 lb, the weight on the drivers, 280,000 lb, and the total weight, 500,000 lb. Table 3 shows other features of the design and estimate as compared with other types of locomotives.

Mr. Michael in his report calls attention to the service of four turbine locomotives, three in Sweden and one in England;

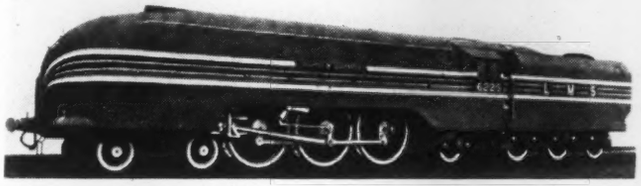


FIG. 7 LOCOMOTIVE OF THE *Princess Coronation* CLASS, ITEM 1 IN TABLE 2

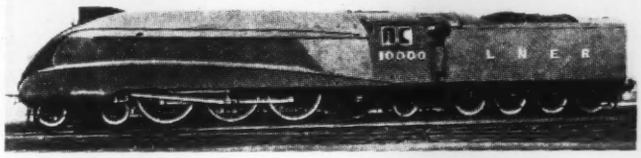


FIG. 8 LONDON & NORTH EASTERN NO. 10,000, AS REBUILT, ITEM 3 IN TABLE 2

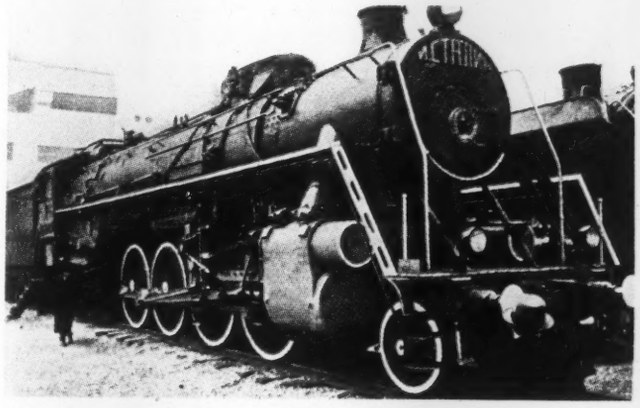


FIG. 9 LOCOMOTIVE OF THE *Josef Stalin* CLASS, ITEM 9 IN TABLE 2

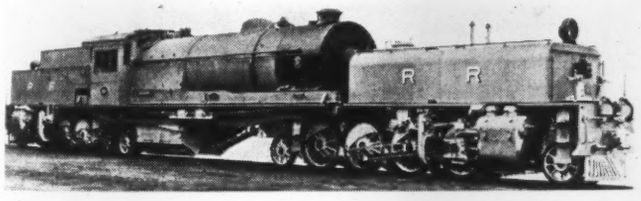


FIG. 10 BEYER-GARRATT LOCOMOTIVE, ITEM 14 IN TABLE 2

FIG. 11 LOCOMOTIVE OF THE *Princess Coronation* CLASS WITHOUT STREAMLINING

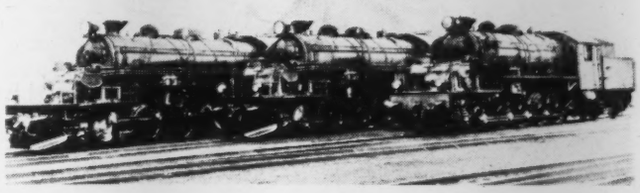


FIG. 12 LJUNGSTROM NONCONDENSING TURBINE LOCOMOTIVES, SWEDISH STATE RAILWAYS

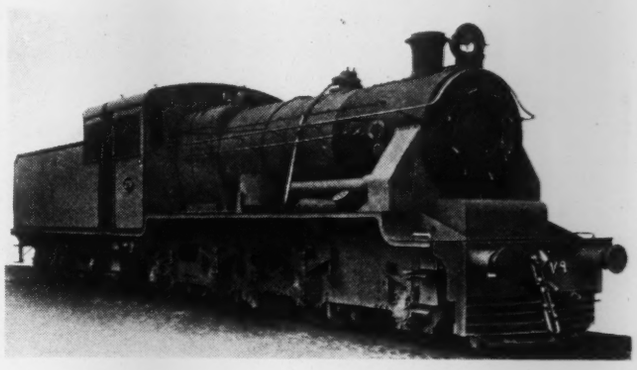


FIG. 13 SENTINEL STEAM-MOTOR-TYPE LOCOMOTIVE, EGYPTIAN STATE RAILWAYS

it was later brought to attention that a Krupp-Zoelly engine on the Continent had been overlooked, also a Ljungstrom engine in Argentina. The British locomotive has been noted in these reports, but not the Swedish engines. The first of these engines was built in 1932, and the first repeat order in 1935–1936. The three locomotives are shown in Fig. 12. The boilers are coal-fired and deliver steam at 185 lb and 750 F to a 1370-hp steam turbine, having a maximum rating of 2000 hp. Turbine and gearbox are placed at the front of the engine in the conventional cylinder position, and drive the eight coupled wheels through jackshafts, connecting rods, and side rods. Reversing is accomplished by meshing an idling gear between two driving gears. Dynamometer records show drawbar pulls as high as 44,000 lb, though the adhesive weight is only 144,000 lb. The locomotives, are used on a particularly difficult stretch of track on the Swedish State Railways, where traffic consists of heavy ore trains. Fuel savings of nearly 25 per cent are found as compared with three-cylinder locomotives in similar service, and maintenance cost is low. It will be noted that these engines operate noncondensing.

Of the steam-motor type of locomotive no example has yet been built in this country, but the projected design of the Baltimore and Ohio has been a matter of general interest. This locomotive is to be of the 4-8-4 type with 400,000 lb total

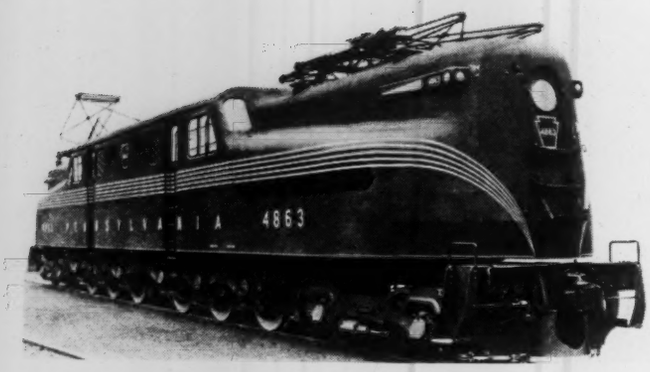


FIG. 14 PENNSYLVANIA ELECTRIC LOCOMOTIVE, CLASS GG1

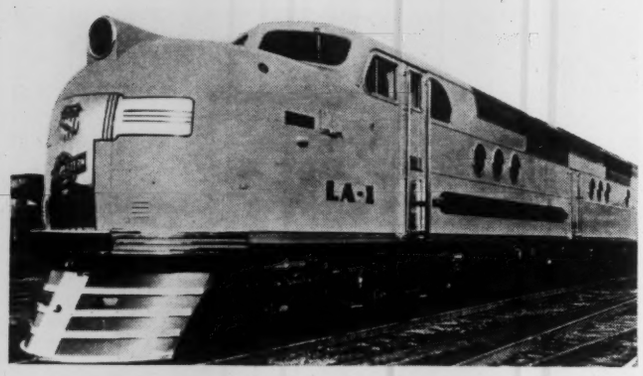


FIG. 15 THE *City of Los Angeles* LOCOMOTIVE, TABLE 4

weight and 280,000 lb on the drivers. It will have sixteen cylinders, four to a driving axle, each $9^1/_2 \times 7$ in., mounted between the wheels in a manner resembling an electric-motor drive. The engine will work at 300 lb pressure and high superheat, and advantages due to elimination of unbalanced reciprocating parts, side rods, and unequal torque are anticipated.

The steam-motor type of locomotive as shown in Fig. 13, is actually in service on the Egyptian State Railways. The wheel arrangement is properly 2-2-2-2 on account of the independence of the driving axles. The engine is of the Sentinel type, long used on rail cars, with four cylinders, two per driving axle. The two cylinders, their crank shaft, and oil-bath gearbox for each axle are entirely enclosed in a casing similar to that of an electric traction motor. Low friction (all internal bearings are of the roller type), high steam economy, and the advantages due to total enclosure which are important under Egyptian operating conditions, are secured.

ELECTRIC LOCOMOTIVES

The outstanding examples of electric-locomotive construction of the year are the Pennsylvania GG1 class, shown in Fig. 14, and new engines for the New Haven, both of which have the same wheel arrangement, 4-6 + 6-4. The principal dimensions and characteristics of both types follow:

	Pennsylvania GG1	New Haven
Electrification system	11000 v ac	11000 v ac, 600 v dc
Electric-locomotive classification	2C + C2	2C + C2
Rating, continuous hp	4620	ac, 3600; dc, 2840
at speed of, mph	90	56 40
Maximum (short time) hp	8500	.....
at speed of, mph	59	.....
Maximum tractive force, lb	72800	.
Weight on drivers, lb	300000	272000
Total weight, lb	460000	432000
Motors: number	6	6
type	twin armature	twin armature
voltage	600 ac	600 dc or ac
Drive	quill	quill

DIESEL-ELECTRIC LOCOMOTIVES

The period has seen continued expansion in the number and power of Diesel-electric units. This had begun in the period of last year's report, and it has been shown that the total orders and installations for Diesel-electric locomotives or power cars from January 1, 1937, to March 1, 1938, substantially equaled the total in the twelve years preceding. Since March 1, 25 additional locomotives have been ordered. Notable among the installed units are the multiple 1800-hp units of the Union Pacific and the Santa Fe. The three-unit *City of San Francisco*

TABLE 4 RECENT DIESEL-ELECTRIC LOCOMOTIVES

Identification	Type	Builder	Details
City of Los Angeles, *City of San Francisco* (U. P.-C. & N. W.-S. P.)	Three units each C + C	Electro-Motive Corp.	1800 hp per unit; total length, 209 ft; total wt, 877,000 lb; six 900-hp General Motors engines; twelve 450-hp traction motors; twelve 8 × 10-in. cylinders per engine developing 900 hp at 750 rpm.
Rockets (C. R. I. & P.)	B + B	Electro-Motive Corp.	1200-hp engine, 16-cylinder V-type; length, 59 ft; wt, 220,000 lb; traction motors on all four axles; tractive force at 60 mph, 6400 lb.
Rebel (G. M. & N.)	B + B	American Car & Foundry Co.	Twelve 8 × 10-in. cylinders, 900 hp at 750 rpm.
El Capitan, *Chicagoan*, *Kansas Cityan*, *San Diegan* (A. T. & S. F.)	B + B	Electro-Motive Corp.	1800 hp similar to *City of Los Angeles* units.
New Orleans Public Belt	B + B	Baldwin Locomotive Works	De La Vergne 900-hp engine, 8-cylinder V-type, 12 × 15-in. cylinders; wt 250,000 lb; tractive force 40,000 lb at 6 mph; continuous rating, 29,500 lb at 9 mph.
Youngstown and Northern	B + B	American Locomotive Co.	900-hp engine with Büchi supercharger to work at 1200 hp; six cylinders, 12 × 13 in.; wt 230,000 lb; maximum tractive force 69,000 lb; continuous tractive force, 30,000 lb at 11 mph.
Rumanian Govt.	4-8-2 + 2-8-4 (2D1 + 1D2)	Winterthur Locomotive Works	Two Sulzer four-stroke engines, 220 hp each at 700 rpm; 12 cylinders, 12.2 × 15.4 in.; Büchi supercharger; eight 390-hp traction motors; tractive force, maximum, 53,800 lb at 21 mph, continuous, 21,500 lb at 62 mph.
Reichsbahn	B + B		MAN Diesel, eight cylinders 11.8 × 15 in.; 1400 hp at 700 rpm; four 300-hp traction motors mounted rigidly on truck frames; linkage drive.

and *City of Los Angeles* with 5400 total hp are the largest yet put into use. These engines consist of a leading or *A*-unit with the characteristic front-end form and the main control station, and two identical *B* units. All can be maneuvered independently for convenience in turning; either one or two *B*-units, or presumably any number, can be coupled to an *A*-unit for road service, all under the control of the *A*-engineman. Fig. 15 shows the *A*-unit and part of the *B*-unit.

The principal characteristics of these and other Diesel-electric locomotives are listed in Table 4.

The most notable foreign Diesel electrics of the year are the 4-8-2 + 2-8-4 for the Rumanian Government, shown in Fig. 16, and the French 4-6-4 + 4-6-4. The latter was given brief note in the preceding report; the Rumanian engine is generally similar except for incomplete streamlining and the substitution of a driving axle for a carrying axle in each running-gear unit.

It is reported that the Reichsbahn now has under construction a Diesel-electric train with several features novel in continental practice. The two engines, of 600 hp each, will be carried within the car body with their generators, rather than on the truck frames. The weight of the car will be carried to the trucks by springs under the floors. There has been put into service during the year a four-car train (power car and three trailers), designed for moderately high speed and partly streamlined, with all bodies on independent trucks. Electric-track-brake blocks as well as the usual automatic air brakes are feature equipment of the power car. The locomotive details are listed in Table 4.

PASSENGER CARS

Table 5 gives the summary of the principal features of a considerable number of new trains, mostly of special lightweight construction which have been installed since the middle of 1937. In some cases, mention of earlier cars delivered was made in the last report.

TABLE 5 NEW PASSENGER TRAINS WITH SPECIAL EQUIPMENT

Identification	Number of trains	Number of cars and make-up
Twentieth Century (N. Y. C.)	4	13 Pullman sleepers and 3 other cars per train. Total car weight 1059 tons.
Broadway Limited (Pennsylvania)	4	13 Pullman sleepers and 3 other cars per train.
Rockets (C. R. I. & P.)	6	Baggage-dinette, 1 or 2 coaches, observation-lounge.
Sunbeams (So. Pac.)	2	Baggage, lounge-dining, 5 coaches, observation.
Crusader (Reading)	5	4 chair cars (2 with observation ends), tavern-diner. Average wt 100,000 lb per car.
City of San Francisco (U. P.-C. & N. W.-S. P.)	1	14 car bodies on 23 trucks per train; each train consists of baggage-dormitory, 2 chair cars, 2 diners, kitchen, club, 7 sleepers, observation-lounge. Average weight 113,000 lb per car body.
City of Los Angeles (U. P.-C. & N. W.)	1	
Super-Chief (A. T. & S. F.)	1	Baggage-dormitory, 3 sleepers, club, diner, 2 sleepers, sleeper-observation.
Chief (A. T. & S. F.)	6	Same as for the *Super-Chief*.
El Capitan (A. T. & S. F.)	2	5-car de luxe-coach train.
Chicagoan, Kansas Cityan (A. T. & S. F.)	2	7-car de luxe-coach train.
San Diegan (A. T. & S. F.)	1	5-car de luxe-coach train.
Rebel No. 3 (G. M. & N.)	1	Power car and sleeper-coach, latter weighing 109,000 lb.

The Pennsylvania and New York Central orders included cars for the complete reequipment of the *Broadway Limited* and *Twentieth Century* trains and the partial reequipment of other "blue ribbon" trains. Fifty-two cars for each railway were built by the Pullman-Standard Car Manufacturing Company to special and, in general, similar designs. These are sleepers, lounge, and observation cars which are owned and operated by the Pullman Company but specially assigned.

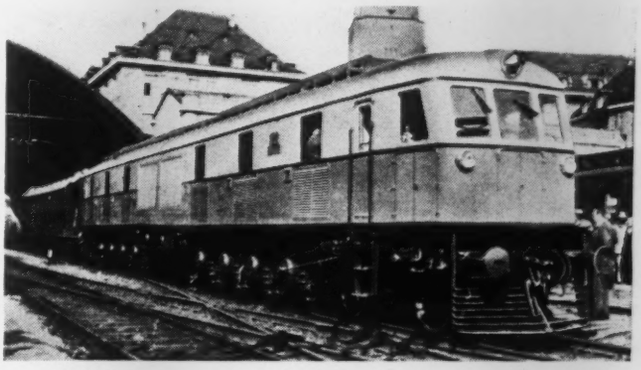


FIG. 16 RUMANIAN GOVERNMENT RAILWAY DIESEL-ELECTRIC LOCOMOTIVE, TABLE 4

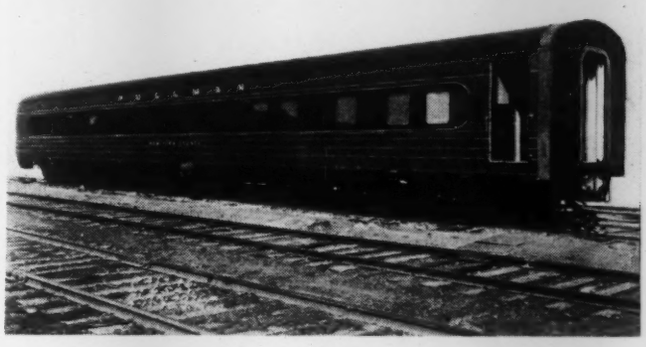


FIG. 17 *Broadway Limited* SLEEPER, PENNSYLVANIA RAILROAD

FIG. 18 NEW YORK CENTRAL *Twentieth Century Limited* DINER

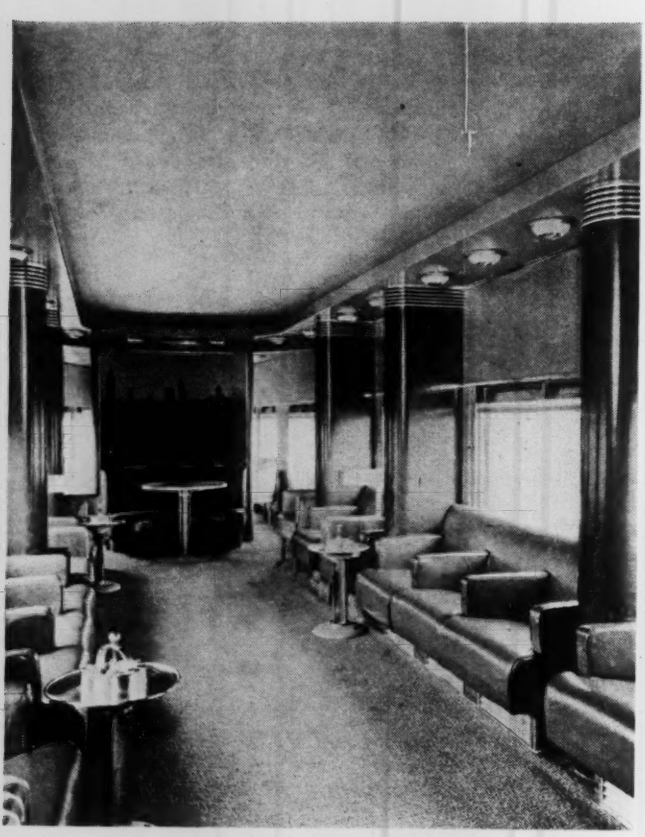


FIG. 19 *Twentieth Century Limited* LOUNGE CAR

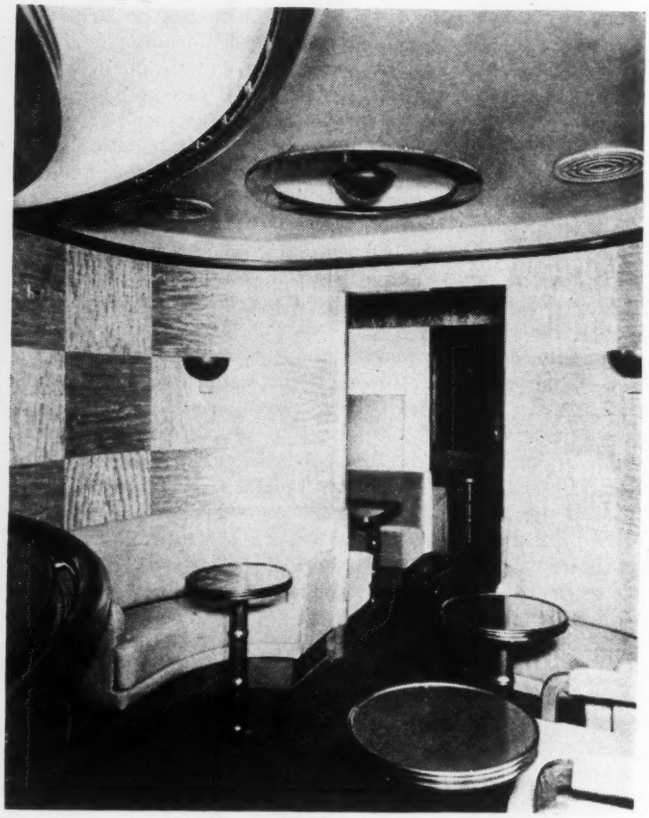


FIG. 20 *Broadway Limited* LOUNGE CAR

Other cars in the Pennsylvania trains were reconditioned by the railway company or built by the Budd Company. Characteristics of all the new cars are four-wheel trucks, roller bearings, oval roofs, deep skirts, and square ends except for the observation cars. Full-width diaphragms are used. The cars included many new features in arrangements and accommodations, and have the attractiveness of the interior enhanced by the use of the most modern ideas in furnishings and decoration.

The Rock Island *Rocket* fleet includes six Diesel-electric locomotives, four three-unit trains and two four-unit trains. The four-unit train includes a three-body articulated unit (baggage-dinette, coach, coach) and an independent observation-lounge car. The three-unit train has but one coach body in the articulated units, but otherwise is identical.

The *City of San Francisco* and *City of Los Angeles* are almost identical; each has 14 car bodies behind the three-unit locomotive, with 23 trucks and five articulation points. At these latter, six-wheel trucks are used. Brake power is 250 per cent based on 100 lb cylinder pressure, and the Dekalakron device for reducing pressure as the speed is reduced insures uniform maximum retardation. These cars are Pullman-built.

The Santa Fe equipment includes 113 cars of Pullman and Budd construction. The Pullman cars are built of high-tensile alloy steel with a maximum amount of welding, and with stainless outside finish. Four-wheel roller-bearing trucks are used, with standard narrow diaphragms applied to square ends.

The Reading *Crusader* makes two daily round trips from Philadelphia to New York. Motive power consists of a remodeled Pacific-type steam locomotive, and the train consists of four chair cars and a tavern-diner; the end chair cars are both equipped with observation-lounge sections and round ends, to avoid the need of turning the train. The cars were built by the Edward G. Budd Manufacturing Company, with the now familiar characteristics of stainless finish, welded Cromansil end construction, square ends, full-width diaphragms, and controlled-slack couplers. A typical car end is shown in Fig. 21, and the interior of one of the end cars in Fig. 22.

New equipment for the Union Pacific–Southern Pacific–Chicago and North Western *Challenger* was installed in the latter part of 1937, and some notice given in last year's report to the earlier cars delivered. Fig. 23 shows one of the later-built chair cars. This order gives the opportunity of comparing weights resulting from three different constructions used on cars of similar size and accommodations:

Chicago and North Western chair cars, Cor-Ten steel, welded-girder construction	112980 lb
Union Pacific cars, riveted-girder type, aluminum alloy	110500 lb
Southern Pacific cars, welded-truss construction, Cor-Ten steel with stainless finish	104600 lb

There are 83 car bodies on this order on 76 sets of trucks, including five two-body kitchen-dining cars, and two double-body chair cars, weighing 207,700 and 202,000 lb, respectively.

One of a group of Atlantic Coast Line chair cars designed for through service to Florida and hence equipped with unusually generous lavatory and lounge facilities, but representing little if any attempt at weight saving, is shown in Fig. 24. These cars weigh 156,500 lb, were built by Bethlehem Steel Company, and have 66 seats in the main body of the car.

The Bangor and Aroostook line has installed an order of light coaches weighing 111,300 lb and similarly constructed buffet-coaches of 117,600 lb. These cars are largely built of Cor-Ten, and have oval roofs, wide vestibules with standard diaphragms, and four-wheel nonequalized trucks. An unusual

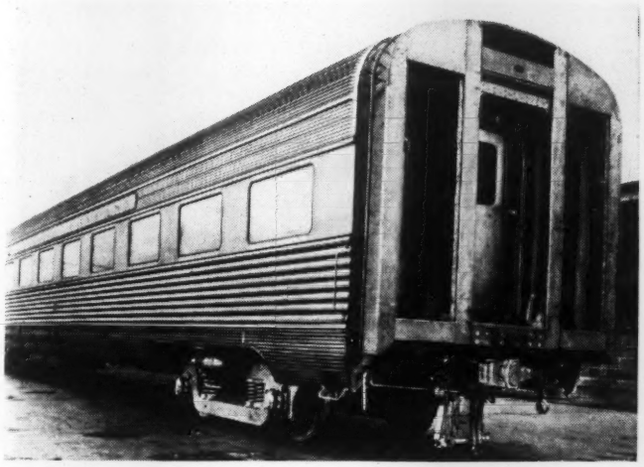


FIG. 21 READING *Crusader* CAR

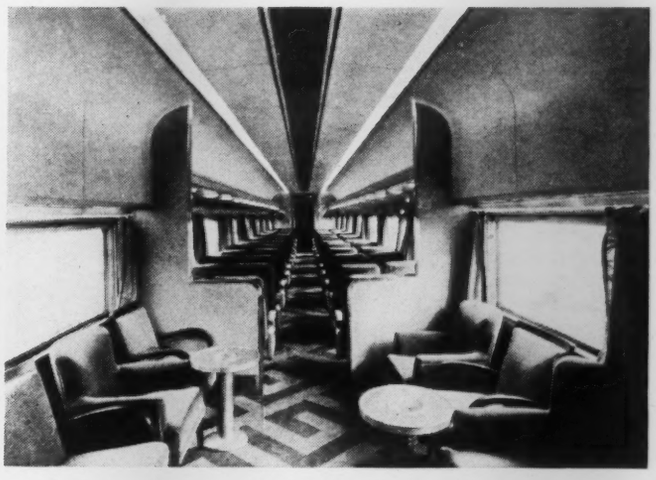


FIG. 22 INTERIOR OF *Crusader* CAR LOOKING FROM LOUNGE END

item in the equipment is an ultraviolet-ray air sterilizer, for use during the winter, when the spray-type air-conditioning system cannot be operated without excessive window condensation.

Other exceptional installations include the addition of a dinette-coach to each of the Twin Cities *Zephyrs*, and a cafeteria car on the New Haven.

Early in the year much attention was attracted to the pendulum car tested by its inventor, C. T. Hill, using Santa Fe facilities. The unit tested consists of an articulated double body on three trucks, and the characteristic peculiarity is the tower-like structure on the center line of each truck, from which the car body is suspended at a point above its center of gravity. The car bodies are only 11 ft high from the rail, but adequate inside height is secured by bringing the floor to within 30 in. of the rail. The gross weight of the double car and three trucks was only 65,000 lb. This extreme lightness was secured in part by the use in the bodies of an adaptation of airplane-fuselage construction, that is, the wrapping of Douglas-fir plywood on a steel frame. Bodies of high-tensile steel in future cars will approach more nearly to normal weights. The truck frames are welded up of light-gage steel members. Longitudinal position of the trucks relative to the car bodies is fixed by rubber-cushioned tubular draft links, and rubber-cushioned lateral restraint is also provided. The main springs are in the suspension towers. Shock absorbers are fitted to dampen resonance and to absorb harmonic vibrations. Figs. 25 and 26 show the general appearance of the cars, and the peculiar truck construction.

The press has not recorded many foreign passenger trains of note; the new equipment for the *Flying Scotsman* and the *Coronation* train are the outstanding examples. The *Scotsman* consists of 14 car bodies, including a three-body articulated unit consisting of a kitchen and two diners. The average weight of the independent cars is 82,000 lb, and the three-body unit weighs 208,000 lb. Construction is of teak on steel underframing. Forced ventilation is used throughout the train. The equipment of the *Coronation* train consists of four two-body units, articulated, and an independent observation car; these cars are steel-sheathed, with stainless moldings and window frames. The two-body units average 160,000 lb each, and the observation car weighs 76,000 lb. The striking beavertail of the latter is shown in Fig. 27.

Passenger-car construction for regular service elsewhere in Europe follows conventional lines, except for some rather startling experiments in interior decoration. The amount of steel used in body construction is definitely on the increase, and several examples of all-steel (or all-metal) bodies are now in use. There has been much more activity in the building of trailers of extremely light weight for Diesel-power cars.

DIESEL-MECHANICAL CARS AND TRAINS

Development along this line has been slow in America, since the reaction in favor of electrical transmission set in many years ago. On the Continent and in Britain many forms of suitable mechanical drive have been produced, of which some of the Continental examples give good results with engine horsepower as high as 500. The nearest to an American example is found in new cars for the Missouri and Arkansas, somewhat similar to the *Zippers* of the Chicago and Eastern Illinois mentioned in last year's report, though the M. & A. cars have gasoline rather than Diesel power. These cars, built by the American Car and Foundry Company, are shown in Figs. 28 and 29. They are powered with a Hall-Scott horizontal engine developing 200 hp.

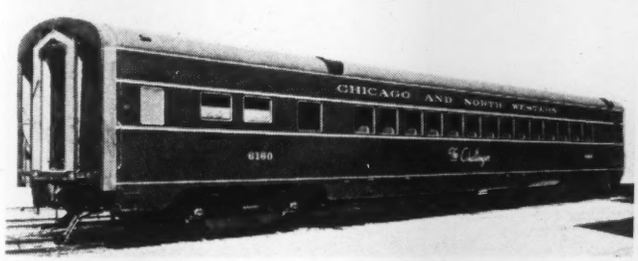


FIG. 23 *The Challenger* CHAIR CAR, CHICAGO & NORTH WESTERN

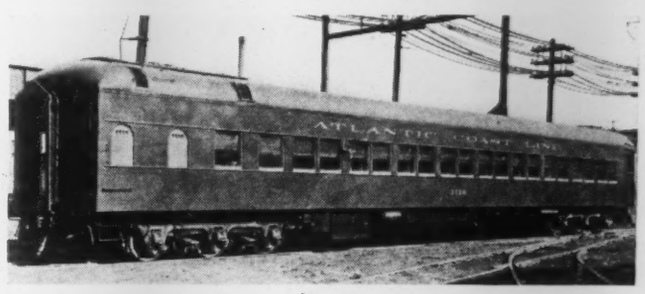


FIG. 24 ATLANTIC COAST LINE COACH

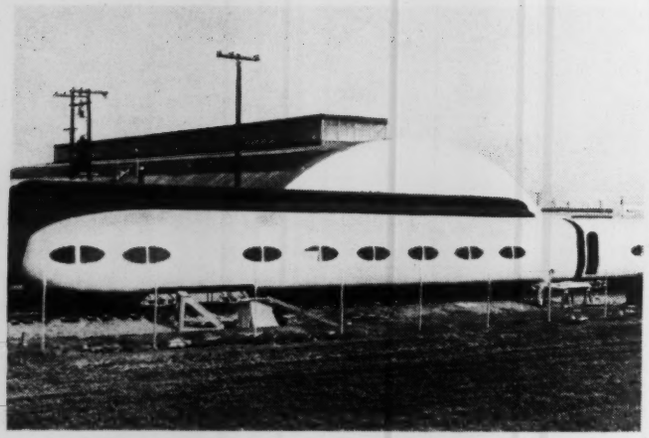


FIG. 25 PENDULUM CAR DEVELOPED BY C. T. HILL

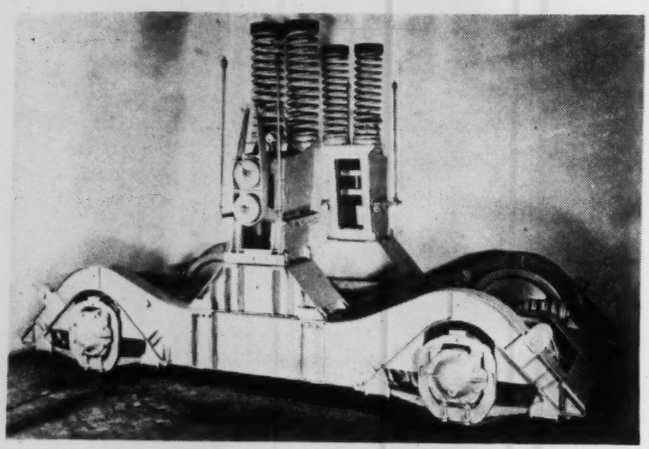


FIG. 26 TRUCK FOR PENDULUM CAR

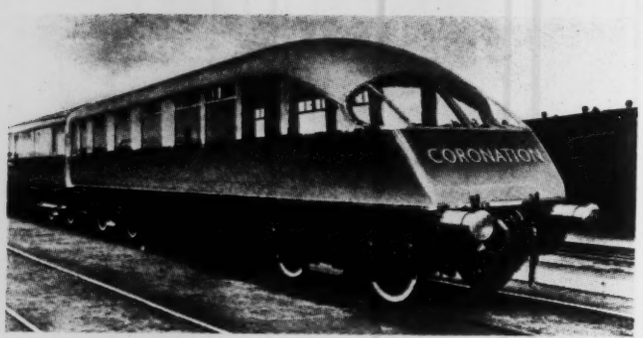


FIG. 27 OBSERVATION CAR OF *Coronation* TRAIN, LONDON AND NORTH EASTERN

FIG. 31 WALKER-TYPE TRAIN FOR THE GREAT NORTHERN (IRELAND)

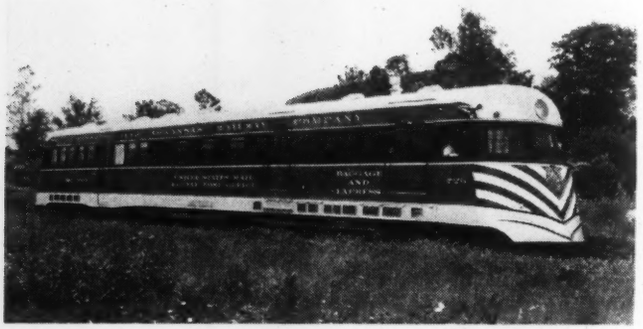


FIG. 28 MISSOURI & ARKANSAS GAS-MECHANICAL CAR

FIG. 29 REAR-END PASSENGER COMPARTMENT, MISSOURI & ARKANSAS GAS-MECHANICAL CAR

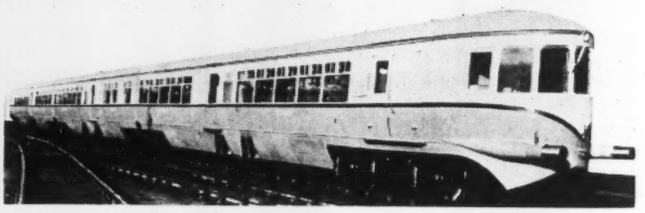


FIG. 30 LONDON, MIDLAND & SCOTTISH DIESEL-MECHANICAL TRAIN

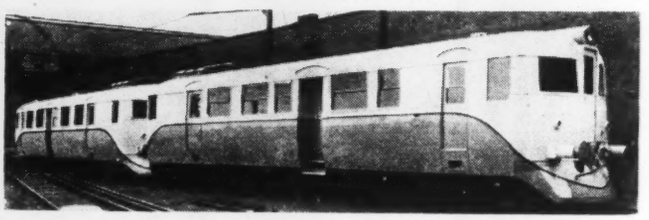


FIG. 32 DREWRY CARS FOR ARGENTINA

Engine, clutch, and transmission unit are rubber mounted on the car underframe. In order to negotiate the heavy grades of the Ozark territory, an auxiliary transmission provides an extra gear reduction. There are thus four forward transmission speeds and the same number for backing, since the power is transmitted to the front axle of the front truck through one of two bevel gears, mounted facing each other on the axle, and the process of reversing consists in shifting the bevel gear on the drift shaft so as to mesh with one or the other of these axle gears. The engines have six $5^1/_4 \times 6$-in. cylinders and develop rated horsepower at 2000 rpm. The weight of the car is 66,150 lb in working order, and a pay load of 18,450 lb including passengers is expected, giving a total weight of 84,600 lb, of which 22,000 lb is on the driving axle. The cars have single-end control, and the space is divided into mail and baggage compartments and seating capacity for 33 passengers, divded between white and colored as provided by law. The total length is 75 ft 7 in. The car is well streamlined, with side skirts extending to within 11 in. of the rail. The trucks have a 6-ft wheel base and 30-in. wheels.

The London, Midland & Scottish has placed in service during the current year a three-car Diesel train with hydraulic transmission. The train is 185 ft long, weighs 163,000 lb, consists of three semistreamlined power-unit cars on four trucks, and accommodates 21 first- and 138 third-class passengers. The power is furnished by six Leyland engines, each with six cylinders $4^1/_2 \times 5^1/_2$ in.; they develop 125 hp each at 2200 rpm, corresponding to a train speed of 75 mph, when the engine shaft is directly connected to the drive shaft through 3.12 /1 gearing. At lower speeds the drive is through a hydraulic torque converter. Freewheeling is provided. The articulation of these trains is of special note: The car-body ends are connected through an articulating link 15 ft long which transmits traction force but carries no weight; at the center of the link the truck swivels. The weight of the bodies is carried to the trucks on radial pads attached to the body which run over rollers on the truck frame. The trucks are welded of steel plates and shapes, and have 36-in. wheels, hollow axles, and roller bearings. The underframe is of welded construction, surmounted by a composite body, with teak framing and metal diagonals. The interior is finished in three-ply veneer with metal moldings; the outside is steel-sheathed, and rubber diaphragms are provided between the bodies. The external appearance of this train is shown in Fig. 30.

The Great Northern Railway (Ireland) has installed several articulated units of the Walker type, as shown in Fig. 31. This construction involves a central power unit on a four-wheel truck so built as to receive the weight of one end of the passenger-car body. The power plant consists of two Gardner engines with six cylinders $4^1/_4 \times 6$ in., delivering 100 hp each at 1700 rpm. Power is transmitted through a Vulcan-Sinclair fluid coupling, through a Wilson five-speed gearbox, to a reversing drive on the axle. Each engine, with pump, cooler, and drive, is entirely independent. The car bodies are 54 ft 5 in. long and the two have a seating capacity of 8 first-, 51 second-, and 105 third-class passengers. The total train is 125 ft 9 in. long and weighs but 92,000 lb ready for service.

The railways of the Argentine have gone heavily into the use of Diesel rail cars, operated in single and multiple units. The largest order involves 107 Drewry cars for the Great Southern, Western, Entre Rios, and North Eastern Railways. Engine, drive, and gearbox are identical with those of the Walker power plant, except that four speeds are provided in the gearbox. The car bodies are 44 ft long, of light welded construction; five different arrangements of interior accommodations are provided, including combinations for baggage and first- and second-class passengers. Transmission speeds range from $11^1/_2$ to $47^1/_2$ mph. Each car has drivers' compartments at both ends, but operation in two- or three-unit groups will be customary and the usual electropneumatic multiple-unit control is provided. Fig. 32 shows two of the cars in multiple-unit operation.

The Italian railways have added a group of all-metal 260-hp cars, with 80 mph top speed, to their already large group of Diesels. These are 75 ft long, with a passenger capacity of 72 and some standing room, and weigh 66,000 lb ready for service. They are operated in single units. The engines are mounted on the bogies and drive the inner axles. An additional order for the Argentine State Railway includes 42 Ganz cars and trains; two three-car trains of this order have mechanical features of special interest. The motive power consists of Ganz-Jendrassik eight-cylinder engines, giving 310 hp at 1250 rpm, directly mounted on six-wheel trucks, of which the inner axle is for weight-distribution purposes only. There is a driver truck at each end of the train; there is no articulation but full-width diaphragms are employed. The total weigh of the train is 360,000 lb and the total length is 253 ft. The Ganz Company is also building single- and multiple-unit cars for the Buenos Aires and Pacific Railway, and high-speed twin-car trains for the Rumanian Railways, both of which involve the usual Continental type of motor truck. The Walker-type tractor unit has been applied to a single-car-body vehicle in light cars for the Paita-Piura Railway (Peru), in 100-hp units. The French, German, and Italian railways continue extensive rail-car programs. In the antipodes, the New Zealand, Queensland, Western Australia, and New South Wales railways are all embarked on Diesel-mechanical-train programs, the most extensive of which is that of the last-mentioned road, with two 360-hp Harland-Burmeister & Wain engines to each power car, and trailers largely constructed of aluminum.

FREIGHT-CAR CONSTRUCTION

The development of greatest current interest in freight-car design is the refinement and lightening of the A.A.R. 1937-standard 50-ton boxcar. Table 6 illustrates what has been done in three cases; it becomes the more important in view of the fact that the standard car represents 3000 lb weight reduction over previous standards.

TABLE 6 GENERAL DIMENSIONS OF RECENT 50-TON BOX-CARS

	A.A.R. 1937 standard	Union Pacific 1937 high-test steel	Mt. Vernon 1935	Pullman-Standard 1937 design
Inside length, ft, in.	40–6	40–6 1/4	40–6	40–6
Inside width, ft, in.	9–2	9–2	8–9	9–2
Inside height at eaves ft, in.	10–0	10–0 1/2	9–4	10–0 1/2
Cubic capacity, cu ft	3711	3730	3316	3712
Wt of car body, lb	29700	25550	22740	21000
Wt of trucks, lb	15600	13450	13660	14600
Total wt, lb	45300	39000	36400	35600
Load limit, lb	123700	130000	132600	133400
Maximum wt on rails, lb	169000	169000	169000	169000
Construction	Carbon steel, riveted	Cor-Ten steel, riveted and welded Yoloy superstructure	Cor-Ten steel, riveted	Cor-Ten steel, arc and spot welded

Figs. 33 and 34 show the Union Pacific and Pullman-Standard designs respectively.

An unusual example of special-purpose car design is found

FIG. 33 UNION PACIFIC LIGHTWEIGHT BOXCAR

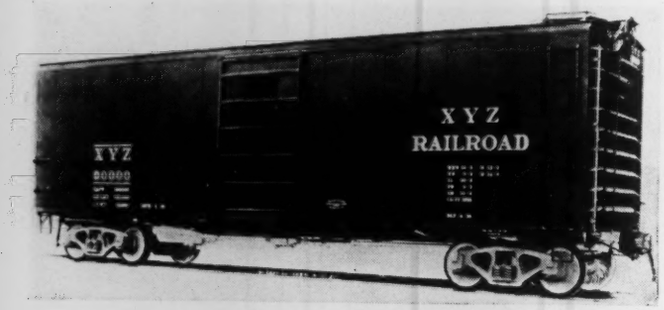


FIG. 34 PULLMAN-STANDARD LIGHTWEIGHT BOXCAR

in the hopper cars reconstructed by the Western Maryland for bulk-cement hauling. Figs. 35 and 36 show the side view and the roof hatches respectively. These cars are 25 ft 9 in. long inside and have a cubage of 1425 cu ft. Loaded with bulk cement to the hatches, the load weighs 121,125 lb, corresponding to the 121,000-lb load limit with a 48,000-lb empty-car weight. The bodies are of combined welded and riveted construction.

The Utah Copper Company has put into service an order of light-weight high-ore cars built of Cumuloy by the Pressed Steel Car Company. These cars have 1660 cu ft capacity, corresponding to a light weight of 45,700 lb. The rail limit for a $6^1/_2$-in. × 12-ft axle is 251,000 lb, hence the load limit is 205,300 lb.

The Delaware and Hudson and the Bangor and Aroostook have recently installed 40-ton boxcars of light weight and exceptional cubage. The cars of the former have prefabricated sides built by the Greenville Steel Car Company and Dreadnought ends; those of the latter were built particularly for the shipment of newsprint, with copper-bearing body sheets and welded seams.

The principal dimensions are as follows:

	Delaware and Hudson	Bangor and Aroostook
Inside dimensions:		
Length, ft, in.	40–6	40–5
Width, ft, in.	8–9	9–$1^1/_2$
Height at eaves, ft, in.	9–$4^1/_2$	9–$2^1/_2$
Capacity, cu ft	3318	3396
Weight, lb	41000	45500
Load limit, lb	95000	90500

The Delaware and Hudson has also put into service experimental all-welded hopper cars of 1752 cu ft capacity (level), 32,700 lb light weight, and 103,300-lb load limit. This limit permits a considerable heap on the loading.

In 1935, the Baltimore and Ohio built five experimental cars of what has come to be known as the "covered-wagon" type, having round tops in place of the familiar flat-roof construction. Tests in service proved these cars so satisfactory that when 1300 wooden-body cars were scheduled for rebuilding in 1936 and 1937, it was decided to replace the old bodies with the new type, which resulted in an increase in cubic capacity of nearly one third.

In June, 1937, the railway started construction of 2000 more "covered wagons" of entirely new design, all of which were completed by March, 1938. These are of fifty tons nominal capacity, but a weight of 46,500 lb permits a load limit of 122,500 lb with $5^1/_2$ × 10-in. journals. The cubic capacity is 3712 cu ft. The underframe and trucks were built by Bethlehem Steel Company. The underframe is of the Duryea cushion type; in this construction the center sills take traction and buffing loads only and the remainder of the framing carries the body loads. The superstructure is formed of a continuous side post and carline in inverted U-form, with the side sheets of copper-bearing steel riveted to the outside of the flanges of the framing angles. The side sheets are continuous from the floor of the car to the center of the roof. The interior lining extends up to the spring of the roof arch.

ACKNOWLEDGMENTS

The compiler acknowledges his indebtedness to the various manufacturers whose equipment is represented in summary and picture in the preceding pages, and to railways which have permitted the use of the pictures; to the magazines *Railway Age*, *Railway Mechanical Engineer*, *Railway Gazette*, *Locomotive*, and *Baldwin Locomotive;* also to Dr. Giesel-Gieslingen who prepared last year's report.

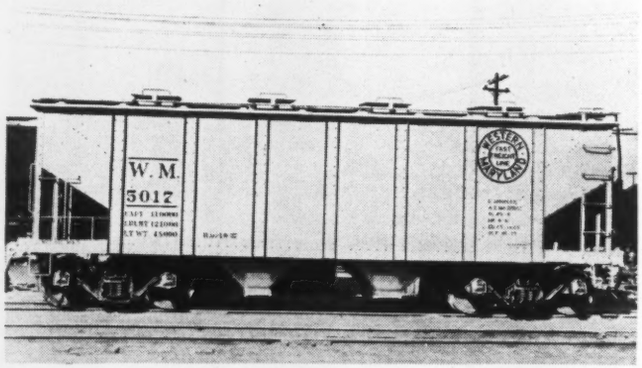


FIG. 35 WESTERN MARYLAND BULK-CEMENT CAR

FIG. 36 ROOF HATCHES OF WESTERN MARYLAND CEMENT CAR

JOB EVALUATION

I—An Analysis of the Several Plans in Use Today

By J. E. WALTERS

PURDUE UNIVERSITY, W. LAFAYETTE, IND.

ONE THIRD of the strikes during the last four years involved the issue of wages and hours. In 1937 there were more strikes and more man-days of idleness because of strikes than in any other year in the history of this country for which strike records are available. Although union recognition is the issue in a large proportion of today's strikes, wages still rank as highly important industrial-relations issues in industry and business. There has been proposed for many years the slogan "a fair day's work for a fair day's wage." Therefore industrial managements have more and more needed to face the question, "What is a fair wage?" As management, and as employees, individually and collectively, try to face this issue more frankly, they must inevitably turn to adequate job evaluations to help ascertain the facts.

Job evaluation is the determination of the value or relative value of each job in a company or industry and the fixing of fair wages for that job. It is the determination of the value of the job and not the value of the employee doing that job. The evaluation of the worker is an entirely separate function. From two aspects, (1) as a means of reducing wage disputes to a minimum and (2) as a means of giving each employee the standard of living to which his job entitles him, job evaluation has a broad social significance.

To the management of each individual concern, proper job evaluation is one of its most important problems of personnel and industrial relations and probably the most vital because it touches daily the life or the very living of each employee. If a company has rated its jobs too high and pays more than the job is worth, its profits will be decreased, it may lose money, and in the end be eliminated as a productive enterprise. If a concern pays too low wages, its employees will not enjoy the standard of living that they deserve and the relationships between the employees and their employer will be none too good.

Some companies try to pay higher than the average wage in order to attract the most efficient workers. Others try to pay slightly lower than the average so that they will not attract workers just for the wage since the companies feel that a certain amount of good will goes with the jobs. However, as a rule, most companies want to pay a fair wage. This fair wage can be determined by means of job evaluation.

Among the more common purposes of adequate job evaluation are:

1 To pay each employee what his job is actually worth according to merit.

2 To attract and retain desirable employees.

3 To prevent inequalities in payments for similar work of the same worth within each department and in the several departments, and to eliminate sources of individual dissatisfaction concerning wages and work.

4 To base the wage of any job upon a factual and scientific basis.

5 To standardize present jobs, and to provide a basis for evaluating new jobs.

6 To provide an adequate basis for promotion of employees from one job to another.

7 To improve employee-employer relations.

8 To promote efficiency in management through the elimination of unnecessary or duplicated activities.

9 To furnish more adequate bases for employment.

Companies have developed a number of types of plans for job evaluation. In order to present an over-all view of these plans, 80 companies were sent letters, asking for descriptions of their job-evaluation plans. Replies were received from 63 companies, of which 32 had established job-evaluation procedures. The remainder either had no definite job-evaluation procedures or very informal plans of accepting the prevailing rate in the community as the value of jobs and of judging new jobs from the old ones. Of the 32 plans upon which this paper is based, 27 were of a formal character and five of a somewhat informal sort. Of the 27 formal plans 17 were of the point-system type, one utilized a combined point and grading system, and nine were based upon the grading method. If this is representative of all American companies, it is apparent that the point system of job evaluation is the most prevalent type. Other investigations have shown that the use of the point system is increasing (11).[1]

In some companies, parts of several types of plans are used. For example, one company uses the point system to evaluate its jobs, checks results by means of the ranking or grading method, obtains information concerning prevailing rates in the community, and then coordinates the results of all three procedures. For some companies it is difficult to segregate or classify the plans into types. Yet the plans of others can be classified readily according to the types described in this paper.

The informal plans have more or less "just grown up" like Topsy, without any definite plan or consideration except, possibly, the prevailing rate in the community or the lowest rate for which the needed manual worker can be obtained. Adherents of the informal plan of simply comparing the rates of one job to that of the community average for that job contend that the elaborate job-evaluation schemes are of little use anyway, because the company has to, or should, pay the prevailing rate of the community, that demanded by the union, or whatever is decided by other means.

The formal plans usually divide themselves into two types:

1 The grading or ranking method

2 The rating or point system of job evaluation.

Considerable discussion of the advantages and disadvantages of the grading and point systems has occurred in the last year or two. Those in favor of the grading or ranking system contend that it is simpler, and easier for the foreman, analyst, and workers to understand. They contend also that it is based upon the judgment of those making the evaluations, which is

Contributed by the Management Division for presentation at the Annual Meeting, New York, N. Y., December 5–9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Recommendation for Occupational Classification or Reclassification

Occupation Name—Present_____ Recommended_____

Section_____ Department_____ Division_____

Present Zone_____ Recommended Zone_____ Date_____

Statement of Duties and Responsibilities (See Reverse Side)

INSTRUCTIONS

STATEMENT OF DUTIES AND RESPONSIBILITIES

1. Describe the kind of work performed; state in some detail the method, process, routine or manner in or by which work is accomplished. Where work is of a general nature, illustrate with typical tasks. Utilize Bedaux S.P.B's where available.
2. State the kind of supervision received and from whom.
3. State the kind of supervision exercised, if any, and over whom.
4. Describe the nature of responsibilities other than supervisory. Consider the extent to which work affects quality of product; the probability of causing delays or damage to equipment; the accountability for conservation of materials such as fuel, steam, air, water, acid, etc.; the possibility of injuring fellow workmen; and related factors.

STATEMENT OF MINIMUM QUALIFICATIONS

1. Formal education (The amount of schooling or equivalent education).
2. Previous mill or trade experience required; what occupations; length of such experience.
3. Knowledge of equipment design, construction and operation necessary for assignment to occupation.
4. Knowledge of methods, practices, principles, processes, product, materials, etc., required for appointment.
5. The required knowledge of technical subjects, such as, chemistry, metallurgy, combustion, mathematics, mechanical drawing, etc.
6. Personal qualifications such as, initiative, tact, resourcefulness, dependability, alertness.
7. Physical qualifications - any unusual requirement as to stature, strength, agility, eyesight, hearing, age, etc.

NATURE AND CONDITIONS OF WORK

1. Posture - Standing, sitting, stooping, etc.
2. Fatigue - Requirement for expenditure of physical or mental effort - the tediousness or monotony of the work.
3. Hazard - Possibility of injury to operator and the probable severity of injury.
4. Surroundings - Disagreeableness of work resulting from unusual heat, cold, dampness, dust, dirt, smoke, fumes, acid, lack of ventilation or illumination, etc.
5. Requirement for skill, accuracy and dexterity.

Checked: Approved and Recommended By:

Superintendent_____ Works Manager

Asst. to Wks. Mgr._____

Note: Retain one copy and send original and three copies to Staff Supervisor of Compensation and Production Standards.

Armco Form No. G-5137

Courtesy American Rolling Mill Company

FIG. 1 OCCUPATIONAL CLASSIFICATION OR RECLASSIFICATION RECOMMENDATION FORM

the same judgment that sets the number of points to be used in the point system. Inversely, they contend that the point system is too theoretical, too hard to understand, too mechanistic, that the jobs cannot be practically evaluated into definite figures as closely as the point system attempts to do. Furthermore they say the point system causes too much argument or too little agreement as to the resulting point values.

Those in favor of the point system contend that it is difficult, if not impossible, to agree upon evaluations through argument and discussion; that the grading system is indefinite and has no definite basis for the evaluation. One industrial engineer said that he just could not get his job-evaluation committee to agree upon the values of different jobs because individual members of the committee placed a sort of a halo over certain jobs and would not agree to their evaluation. The argument continued until they finally discarded the grading system and adopted the point system which, he said, settled the argument by its definiteness and by having each member of the committee rate the jobs in question. Those in favor of the point system also contend that almost anything worth-while is difficult; that the point system is definite and more scientific than the grading system; that through proper training it can be understood by all those concerned; and that it furnishes management with a more definite basis for presenting job evaluations to the employees, individually or collectively through a union.

The discussion of the advantages and the disadvantages could continue at length. From the various plans themselves, it is evident that one plan might be better adapted to one company whereon the other would be better for another concern. Probably both types of plans can accomplish the results desired, if given an opportunity.

THE INFORMAL PLANS OF JOB EVALUATION

The informal plans of evaluating jobs involve the comparison of rates with those of the other companies in the community and taking as the value of each job the prevailing rate. The following descriptions show how these informal plans work:

Company A. To arrive at pay rates for certain classes of work, we cooperate with a large number of manufacturers, getting their breakdown of the various jobs and the rates of pay paid by each for each classification of work and let this govern us to a large degree in determining our wage rates.

Company B. We have never had the problem that some concerns have in evaluating jobs. In the first place, most of the important jobs in our business are highly skilled jobs which have been well-defined over a period of fifty years or more. This is also due to the fact that the various crafts unions in our locality have definite scales of pay which evaluate each job. We have made it a practice to pay our men with an eye to what they might receive in similar employment elsewhere.

Some twenty-five years ago we undertook the establishment of a bonus system and in order to do this we had to time study and analyze each job in the factory. The natural result of this process was that each job was evaluated.

Since in some of our unskilled groups there is differentiation between classes of work, we have made a study, probably not a very scientific one, to determine which job carried the most value and so adjusted our rates of pay and lines of promotion as to reflect these differences.

THE GRADING SYSTEM OF JOB EVALUATION

The grading system usually consists of the following steps:

1 Making of job descriptions
2 Grading or ranking of jobs according to value
3 Correlation of job values with present wages
4 Adjustment of wages.

The first step in the job-grading system is to make a complete description of each job to be evaluated. These job descriptions are prepared in several ways. The Socony-Vacuum Oil Company has each employee write a description of his job on a job description blank which is first reviewed, edited, and revised by the employee's supervisor and the industrial relations department, and then by the job analyst. When the finished job descriptions are ready, it is then possible to rank the positions by departments.

A majority of the companies, which use the grading or ranking method, have a job analyst, or a member of the personnel department, interview each employee and from that interview make a detailed description of the position on a job-description form especially prepared for that purpose. Figure 1 shows the blank together with instructions used for this purpose by the American Rolling Mill Company (1).

In ranking jobs, there are several procedures employed. One method is to select two key jobs because of their extreme difference in value and then to rank the jobs in each department from lowest to highest according to the value of the work in the opinion of those making the rankings. Some companies have a list of factors which they consider in making this ranking, such as the following list used by the Socony-Vacuum Oil Company:

1 Difficulty of work
2 Volume of work

3 Responsibility involved
4 Supervision required
5 Supervision of others
6 Knowledge, training, experience necessary
7 Conditions under which work is done.

However, these are considered not specifically but generally, and the different factors are not weighted or given a point value in making the ranking. In some companies, this ranking is done by a job analyst, especially selected and trained for that work; in others, by a committee; and in still others, by a member of the personnel department. The grading is then reviewed by the superintendent or foreman of the department concerned, and revisions made in light of discussions of high and low rankings.

The Kimberly-Clark Corporation reviews and discusses its ranking of jobs with the representatives of the employees. The company feels that this democratic process brings about a better understanding and sincerity. During all discussions about the job rankings and gradings, changes may be made until a final ranking of jobs is agreed upon and approved by the management.

Usually, after the jobs are ranked by departments, a comparison of rankings in each department is made with those of similar departments. Where differences of opinion show up by this ranking in the different departments, adjustments are usually made after a discussion between the job analyst and the superintendents, foremen, or department heads, resulting in the ranking of jobs in the company as a whole.

After all the jobs are ranked from lowest to highest, they are usually divided into groups from lowest to highest. The American Rolling Mill Company has divided its jobs into eighteen groups, whereas the Goodyear Tire and Rubber Company classifies its jobs into six groups. Fig. 2 shows average daily earnings assigned to each zone or grade in an individual plant (chart *A*) and in all plants (chart *B*) of the American Rolling Mill Company. Chart *C* shows the smoothed-out averages for each zone and the base rate curve.

After the chart showing the evaluations of zones and rates for wages has been made, the actual rates or wages paid are often plotted upon the chart for comparative purposes. Discrepancies due to too high or too low wages can then be readily seen and the positions where attention should be paid to wage adjustments immediately become apparent.

Some of the companies who apparently have had good success with the grading system of job evaluation are: The Socony-Vacuum Oil Company, American Rolling Mill Company, Kimberly-Clark Corporation, Cincinnati Milling Machine Company, Goodyear Tire and Rubber Company, Leeds and Northrup Company, and the Frigidaire Corporation.

THE POINT SYSTEM OF JOB EVALUATION

The point system of job evaluation is an attempt to make the evaluation of jobs more definite and more scientific than by the grading method. The job is divided into its factors and those factors are weighted according to their value. Then by rating the job on each factor according to the points assigned, a numerical value in points for the job results.

The steps in evaluating jobs by the point system are usually as follows:

1 The selection of job factors
2 The weighting of the job factors in points
3 The preparation of job-description, job-analysis, and point-rating forms
4 The description, rating, and evaluation of all the jobs
5 The correlation of the point values with rates or wages

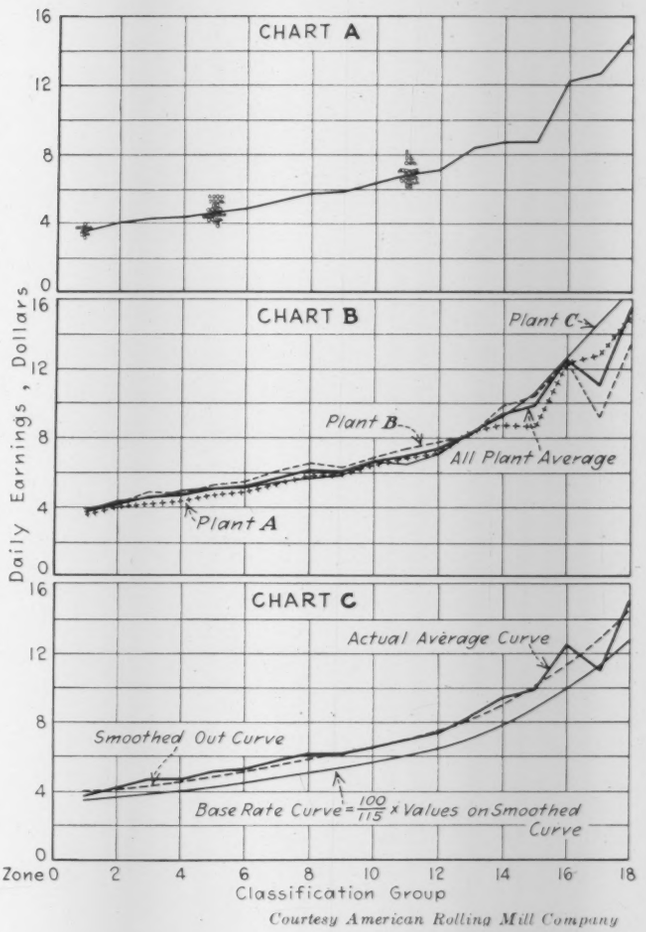


FIG. 2 CHARTS OF DAILY EARNINGS AND CLASSIFICATIONS
Chart *A*—Individual plant average
Chart *B*—All plant averages
Chart *C*—Smoothed-out curve and base rate curve

6 The adjustment of wages which are too high and too low for the value of the job.

The first step in the point system, the selection of job factors, is that of deciding within the individual company the essential factors of typical jobs. Some companies simply accept the point systems as worked out by their own or other trade associations or professional societies, and adapt those point systems to their particular company, changing them to meet local conditions. Examples of such association and society point systems are those of the Industrial Relations Department of the National Electrical Manufacturing Association (9) and the Industrial Management Society of Chicago (7). To judge from this study more companies are modeling their job evaluation systems on those two plans than any others.

In some companies a committee of the officers, principally concerned with job evaluation, meet and discuss the various job factors which are essential in that particular company. In one company, each of the various persons responsible for job evaluation made a list of the essential factors and weighted them; then a composite list of factors and weightings was made from these individual lists of factors and weightings. This was followed by discussions of the various points until the factors and their point values were agreed upon. The total number of points assigned to the evaluation seems to be somewhat arbitrary and appears to make but little difference in the final

TABLE 1 POINTS ASSIGNED TO FACTORS AND KEY TO GRADES

(From "Job Rating," National Electrical Manufacturers Association, Bulletin No. 43, 1937)

	Factors	1st degree	2nd degree	3rd degree	4th degree	5th degree
	Skill					
1	Education	14	28	42	56	70
2	Experience	22	44	66	88	110
3	Initiative and ingenuity	14	28	42	56	70
	Effort					
4	Physical demand	10	20	30	40	50
5	Mental or visual demand	5	10	15	20	25
	Responsibility					
6	Equipment or process	5	10	15	20	25
7	Material or product	5	10	15	20	25
8	Safety of others	5	10	15	20	25
9	Work of others	5		15		25
	Job Conditions					
10	Working conditions	10	20	30	40	50
11	Unavoidable hazards	5	10	15	20	25
	Total points					500

The total number of points (score) determines the job grade as follows:

Score range	Men's grades	Women's or boys' grades
... 139	..	25
140–161	..	24
162–183	10	23
184–205	9	22
206–227	8	21
228–249	7	..
250–271	6	..
272–293	5	..
294–315	4	..
316–337	3	..
338–359	2	..
360–381	1	..

TABLE 2 SUMMARY OF JOB REQUIREMENTS

(From "Industrial Relations Manual," Westinghouse Elec. & Mfg. Co., 1936)

I	Knowledge and Training Required—65 per cent	
	(*A*) Basic education	0–100
	(*B*) Knowledge of methods & equipment or experience	0–100
	(*C*) Initiative and ingenuity or manual skill or ability	0–125
II	Specific Demands of Job—20 per cent	
	(*A*) Physical application	0–40
	(*B*) Mental or visual application	0–40
	(*C*) Unusual features	0–20
III	Responsibilities Involved—15 per cent	
	(*A*) For equipment	0–25
	(*B*) For product	0–25
	(*C*) For safety of others	0–25
	Total Points	0–500

result within the company. However, where the point values differ it is difficult to compare similar jobs in different companies by the comparison of assigned point values. Table 1 shows the method of determining the point values suggested by the Industrial Relations Department of the National Electrical Manufacturers Association (9). The Westinghouse Electric and Manufacturing Co. (18) determines the essential factors in percentages and then subdivides the three main factors, assigning the point values as shown in Table 2.

The definition of each factor varies with different companies and organizations. The six characteristics used by the General Electric Co. (4) are shown in Table 3. "By mentality is meant schooling, acquired either in a formal or an informal way, that an individual must have before he can qualify to learn the job in question. Skill is defined as learning time. By this is

TABLE 3 JOB CHARACTERISTICS AND WEIGHTS

(From "Job Evaluation," General Electric Co., 1938)

Characteristics	Relative weights High	Low
Mentality	100	0
Skill	400	0
Responsibility	100	0
Mental Application	50	0
Physical Application	50	0
Working Conditions	100	0

meant the total time spent in various assignments that is necessary before an individual is qualified for the job in question, plus the normal amount of time required on the job so that he is competent to do that job in an expeditious manner. Responsibility is measured by the chance of error and its probable cost either in materials or machinery. Application, either mental or physical, is the degree and continuity of such application performed on the job. Working conditions refer to conditions surrounding a job which make it less desirable than the ordinary job from the point of view of the type of operator required."

With these definitions as a basis the General Electric Company selects key jobs having the highest and lowest ratings in each characteristic. Lists of some fifty key jobs have been developed. Each job is then evaluated on each separate characteristic by a comparison of that job to the key jobs in that characteristic. This is to a certain extent a combination of the ranking and point systems.

The most common method of defining job factors in the companies is to divide each factor into degrees from lowest to highest of that factor, such as the definition for initiative and ingenuity under *Skill* by the National Electrical Manufacturers Association (9).

"Initiative and ingenuity," as defined, "relate to the job requirements of ability for original conception, independent action, or exercise of judgment and are classified under five degrees. The first degree requires the ability to understand and follow simple instructions and the use of simple machines, gages, and fixtures, where no decisions are required, since the employee is told exactly what to do. The second degree requires the ability to perform general operations from detailed instructions and the making of minor decisions, requiring some judgment on the part of the employee. The third degree requires the ability to understand and plan sequence of operations, where standard methods of procedure are available and the making of general decisions by the employee, within the limitations of standard methods, is possible. The fourth degree requires a high degree of ability to understand, plan course of action and perform work where only general methods of procedure are available. It requires the use of individual ingenuity, initiative, and judgment. The fifth degree requires outstanding ability to think clearly, accurately, and independently on complicated work not having standard methods of procedure. It also requires a high degree of ingenuity, initiative, and judgment."

Based on these definitions, the analyst is able to judge into which degree the particular job falls with respect to that factor. The point rating, having been already agreed upon for that degree, is thus simultaneously set.

Another method is to prepare tables for the correlation of the degree of the factor required by the job and the percentage of time that that factor is exercised. The United States Steel Corporation (15) has prepared an excellent job-evaluation manual for its subsidiary companies to use in evaluating their jobs. Fig. 3 shows a sample guide chart from this manual used in determining the value of the mental-effort factor in a job.

When the factors and their values have been decided upon, a job description and evaluation blank is usually prepared for describing each job and evaluating it. Fig. 4 shows the form developed and recommended by the National Electrical Manufacturers Association (9), and Fig. 5 is a sample form for describing and evaluating jobs in the United States Steel Corporation (15). The National Metal Trades Association (10) has gone one step further and prepared sample ratings on certain key jobs, such as boring-mill operator, and added exemplary substantiating data which facilitate more accurate decisions as to the degrees and thereby the points to be assigned to the factor of a job. The job analysts, the industrial engineer, or the representative from the personnel department uses such forms as these in describing and evaluating each job, basing his evaluation upon interviews with each employee, the foreman, and all others who may know the details of that particular job. After the job is evaluated according to the several factors the total points for each job are determined by adding the points given for each factor. The jobs are then listed from the lowest to the highest by departments, divisions, or by the company as a whole. When this has been done the rate or wages paid, or to be paid, can be correlated with the point values for each job. The actual rates or wages can then be added on the chart to show the discrepancies which exist between the amount paid for the job and its evaluated worth

If the rate or wage is relatively lower than it should be according to the evaluation, the company usually takes the first means possible to bring the wage up to the value. If the employee is being paid more than the job is worth according to the evaluation, the usual solution is to wait, letting labor turnover cause a change of employees on that job, and then pay the reduced rate to the new employee. The increases and decreases often equalize themselves. In a steel company the evaluation process decreased the pay roll 4.6 per cent. The revision of rates and wages in another company resulted in an approximate 0.5 per cent increase in the pay roll.

After every job has been evaluated in terms of points, a chart is usually prepared beginning at the base rate for the evaluation of the lowest job ascending through the various jobs according to their values to the highest valued job, as shown in Fig. 6. Such a graph can then be used in finding the rate or the wage for new jobs that are subsequently evaluated by this point system.

As the details of the job-evaluation plans vary so greatly, it is impossible to tell in such a short time and space the types or parts of the various systems which appear to be the best for different kinds of companies. However, it is hoped that the most essential philosophy and procedures of job evaluation have been presented.

CONCLUSION

Up to this point the author has tried to present an unbiased or impersonal view of the types of job-evaluation plans, in the hope of giving sufficient material so that the management of a company which wishes to develop a system of job evaluation can do so from the descriptions given here or available from the sources suggested.

After reviewing the job-evaluation plans of the 32 companies and because of the fact that about twice as many of the com-

Characteristics of Operation		Speed of Operation	Per Cent of Turn Exercised				
			V	W	X	Y	Z
			0 10	11 30	31 50	51 70	Over 70
A— Variations few and simple. Tasks become practically automatic. Duties highly repetitive and learned in a short time. Duties non-repetitive but of such nature that methods are obvious. Decisions established by frequent repetition of similar conditions.	J—Immediate actions are not controlled by other men, processes or machines. Attention to co-ordinate actions with others not required.	S—Moderate	1	5	10	15	20
		T—Fast	1	5	10	20	25
		U—Extremely Fast	2	5	15	20	30
	K—Attention required to coordinate manual actions closely with other men, processes or machines. Example: Catcher-piler.	S—Moderate	1	5	15	20	25
		T—Fast	2	10	15	25	30
		U—Extremely Fast	2	10	20	30	40
	L—Makes routine decisions. Selects. Inspects and marks or assorts.	S—Moderate	2	10	20	25	35
		T—Fast	3	10	20	30	40
		U—Extremely Fast	3	10	25	35	50
B—Tasks wherein variations are many and complex. Performance does not become automatic. Decisions not established by frequent repetition of similar conditions. Attention is required to vary speed, swing or travel of power-driven equipment.	J—Immediate actions are not controlled by other men, processes or machines, but duties are obvious or instructions are simple.	S—Moderate	3	10	25	35	45
		T—Fast	3	15	30	40	55
		U—Extremely Fast	4	15	30	45	60
	K—Attention is required to co-ordinate closely manual actions with other men, processes or machines. Attention constantly focused upon an operation to discern variations to which immediate response must be made.	S—Moderate	4	15	30	45	60
		T—Fast	4	20	35	55	70
		U—Extremely Fast	5	20	40	60	80
	L—Attention to interpret detailed instructions. Attention to analyze and solve complex problems. Attention to plan complex operations.	S—Moderate	5	20	40	60	80
		T—Fast	6	25	45	70	90
		U—Extremely Fast	7	25	50	75	100

Courtesy U. S. Steel Corporation

FIG. 3 GUIDE CHART FOR DETERMINING MENTAL-EFFORT FACTOR

JOB RATING SHEET

JOB NAME AUTOMATIC SCREW MACHINE OPERATOR DEPT. SCREW MACHINE JOB NO.

GENERAL JOB DESCRIPTION

Set up and operate automatic screw machines, such as #00, #0 and #2 Brown & Sharpe Single Spindle or 9/16" and 1" Acme Multi-Spindle.

JOB REQUIREMENTS

MAN WOMAN BOY SPEC. AGE REQ. 30-45 years

HRS. OF WK. (IF NOT REG.) Regular

REQUIRED EXPER. PREV. JOBS TIME 3 to 5 years on same or similar types of machines

APPRENTICESHIP Yes

DAY WORK RATE		AVE. HOURLY EARNINGS	OCCUPATIONAL WAGE
START	MAXIMUM		
.85		$1.05	$1.02

JOB ATTRIBUTES	OBSERVERS EVALUATION					
	1ST DEG.	2ND DEG.	3RD DEG.	4TH DEG.	5TH DEG.	POINTS ASSIGNED
SKILL						
EDUCATION			✓			42
EXPERIENCE				✓		80
INITIATIVE & INGEN.				✓		56
EFFORT						
PHYSICAL DEMAND		✓				20
MENTAL OR VIS. DEMAND				✓		80
RESPONSIBILITY						
EQUIPMENT OR PROCESS			✓			15
MATERIAL OR PRODUCT		✓				10
SAFETY OF OTHERS			✓			15
WORK OF OTHERS			✓			15
JOB CONDITIONS						
WORKING CONDITIONS				✓		40
UNAVOIDABLE HAZARDS			✓			15

TOTAL POINTS 336

LABOR GRADE 3

DETAILED DUTIES

1. Get necessary cams, chucks, tools, etc. from tool crib according to job layout.
2. Set up and adjust machine.
3. Grind and sharpen cutting tools and blades.
4. Operate group 2 to 5 machines depending on work requirements.
5. Determine proper feeds and speeds, where not specified.
6. Maintain tool set-up.

SPECIAL QUALIFICATIONS

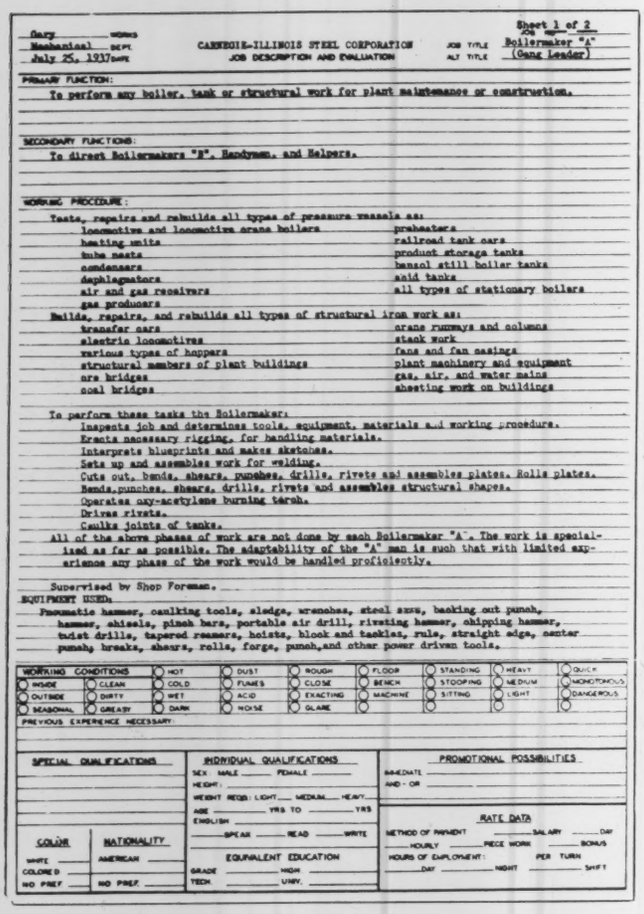
1. Work from prints and job layouts.
2. Able to select proper cams, tools, chucks, cutters, blades, etc. if not specified on layout.
3. Work to close tolerances using complicated tool set-ups.
4. Able select proper cutting lubricant.
5. May direct the work of helpers.
6. Education equivalent to grammar school plus 4 years apprenticeship.

SAFETY REGULATIONS AND HAZARDS

Remote possibility of dermatitis from cutting oils and lubricants.

Courtesy N.E.M.A.

FIG. 4 JOB RATING SHEET



CARNEGIE-ILLINOIS STEEL CORPORATION
JOB DESCRIPTION AND EVALUATION

Sheet 1 of 2
JOB TITLE Boilermaker "A"
ALT TITLE (Gang Leader)

Gary WORKS
Mechanical DEPT.
July 25, 1937 DATE

PRIMARY FUNCTION:
To perform any boiler, tank or structural work for plant maintenance or construction.

SECONDARY FUNCTIONS:
To direct Boilermakers "B", Handymen, and Helpers.

WORKING PROCEDURE:
Tests, repairs and rebuilds all types of pressure vessels as:

locomotive and locomotive crane boilers	preheaters
heating units	railroad tank cars
tube nests	product storage tanks
condensers	benzol still boiler tanks
dephlegmators	acid tanks
air and gas receivers	all types of stationary boilers
gas producers	

Builds, repairs, and rebuilds all types of structural iron work as:

transfer cars	crane runways and columns
electric locomotives	stack work
various types of hoppers	fans and fan casings
structural members of plant buildings	plant machinery and equipment
ore bridges	gas, air, and water mains
coal bridges	sheeting work on buildings

To perform these tasks the Boilermaker:
Inspects job and determines tools, equipment, materials and working procedure.
Erects necessary rigging, for handling materials.
Interprets blueprints and makes sketches.
Sets up and assembles work for welding.
Cuts out, bends, shears, punches, drills, rivets and assembles plates. Rolls plates.
Bends, punches, shears, drills, rivets and assembles structural shapes.
Operates oxy-acetylene burning torch.
Drives rivets.
Caulks joints of tanks.
All of the above phases of work are not done by each Boilermaker "A". The work is specialized as far as possible. The adaptability of the "A" man is such that with limited experience any phase of the work would be handled proficiently.

Supervised by Shop Foreman.

EQUIPMENT USED:
Pneumatic hammer, caulking tools, sledge, wrenches, steel saws, backing out punch, hammer, chisels, pinch bars, portable air drill, riveting hammer, chipping hammer, twist drills, tapered reamers, hoists, block and tackles, rule, straight edge, center punch, breaks, shears, rolls, forge, punch, and other power driven tools.

WORKING CONDITIONS								
INSIDE	CLEAN	COLD	FUMES	CLOSE	BENCH	STOOPING	MEDIUM	MONOTONOUS
OUTSIDE	DIRTY	WET	ACID	EXACTING	MACHINE	SITTING	LIGHT	DANGEROUS
SEASONAL	GREASY	DARK	NOISE	GLARE				

PREVIOUS EXPERIENCE NECESSARY:

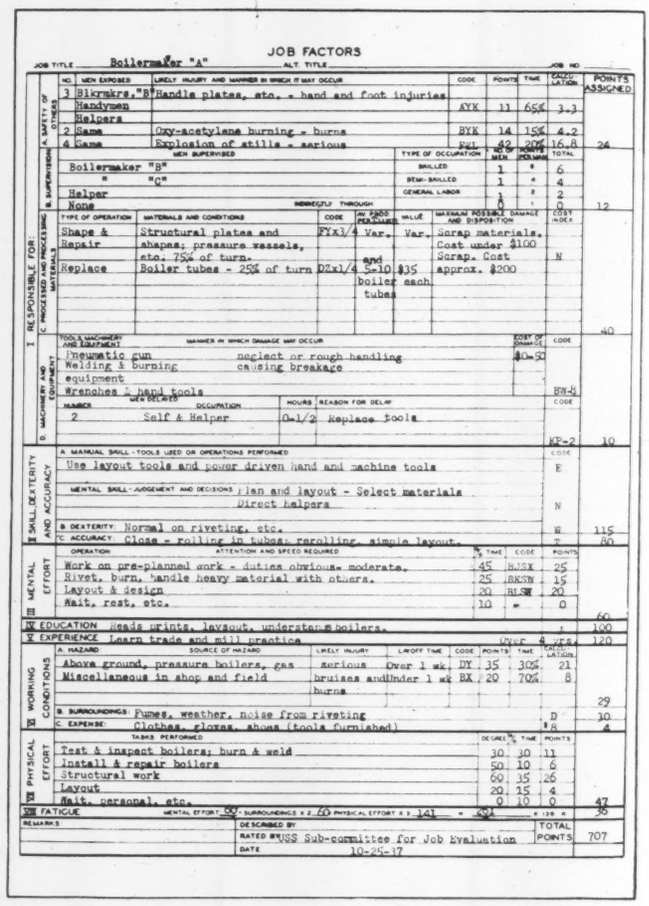
SPECIAL QUALIFICATIONS

INDIVIDUAL QUALIFICATIONS
SEX: MALE FEMALE
HEIGHT:
WEIGHT REQD: LIGHT MEDIUM HEAVY
AGE YRS TO YRS
ENGLISH: SPEAK READ WRITE
EQUIVALENT EDUCATION
GRADE HIGH
TECH UNIV.

PROMOTIONAL POSSIBILITIES
RANK/DATE
AND - OR

RATE DATA
METHOD OF PAYMENT SALARY DAY
HOURLY PIECE WORK BONUS
HOURS OF EMPLOYMENT: PER TURN
DAY NIGHT SHIFT

COLOR: WHITE, COLORED, NO PREF.
NATIONALITY: AMERICAN, NO PREF.



JOB FACTORS

JOB TITLE Boilermaker "A" ALT TITLE JOB NO

A SAFETY OF OTHERS

NO. MEN EXPOSED	LIKELY INJURY AND MANNER IN WHICH IT MAY OCCUR	CODE	POINTS	TIME	CALCULATION	POINTS ASSIGNED
3 Blkrmkrs. "B"	Handle plates, etc. - hand and foot injuries					
Handymen		AYK	11	65%	3.3	
Helpers						
2 Same	Oxy-acetylene burning - burns	BYK	14	15%	4.2	
4 Same	Explosion of stills - serious	BXL	40	20%	16.8	24

B SUPERVISION — MEN SUPERVISED

TYPE OF OCCUPATION	MEN DIRECTLY	MEN INDIRECTLY	TOTAL
Boilermaker "B"	1	6	6
" "C"	1	4	4
Helper	1	2	2
None	0	0	0

INDIRECTLY THROUGH

C RESPONSIBLE FOR: PROCESSED AND PROCESSING MATERIALS

TYPE OF OPERATION	MATERIALS AND CONDITIONS	CODE	AV. LOSS PER MACHINE	VALUE	MAXIMUM POSSIBLE DAMAGE AND DISPOSITION	COST INDEX
Shape & Repair	Structural plates and shapes; pressure vessels, etc. 75% of turn.	FYx1/4	Var.	Var.	Scrap materials. Cost under $100	N
Replace	Boiler tubes - 25% of turn	DZx1/4	5-10 and boiler each tubes	$35	Scrap. Cost approx. $200	
						40

D MACHINERY AND EQUIPMENT

TOOL & MACHINERY AND EQUIPMENT	MANNER IN WHICH DAMAGE MAY OCCUR	COST OF DAMAGE	CODE
Pneumatic gun	neglect or rough handling	$0-50	
Welding & burning equipment	causing breakage		
Wrenches & hand tools			BW-6

NUMBER MEN DELAYED	OCCUPATION	HOURS	REASON FOR DELAY	CODE
2	Self & Helper	0-1/2	Replace tools	
				KP-2
				10

E SKILL-DEXTERITY AND ACCURACY

A MANUAL SKILL - TOOLS USED OR OPERATIONS PERFORMED: Use layout tools and power driven hand and machine tools — CODE E

MENTAL SKILL-JUDGEMENT AND DECISIONS: Plan and layout - Select materials. Direct helpers — N

B DEXTERITY: Normal on riveting, etc. — W — 115

C ACCURACY: Close - rolling in tubes; rerolling, simple layout. — T — 80

F MENTAL EFFORT

OPERATION	ATTENTION AND SPEED REQUIRED	% TIME	CODE	POINTS
Work on pre-planned work - duties obvious - moderate.		45	BJSX	25
Rivet, burn, handle heavy material with others.		25	BKSN	15
Layout & design		20	BLSW	20
Wait, rest, etc.		10	"	0
				60

IV EDUCATION: Reads prints, layout, understands boilers. — I — 100

V EXPERIENCE: Learn trade and mill practice — OVER 4 YRS. — 120

G WORKING CONDITIONS

A HAZARD

SOURCE OF HAZARD	LIKELY INJURY	LAYOFF TIME	CODE	POINTS	% TIME	CALCULATION	
Above ground, pressure boilers, gas	serious	Over 1 wk.	DY	35	30%	21	
Miscellaneous in shop and field	bruises and burns	Under 1 wk.	BX	20	70%	8	
							29

B SURROUNDINGS: Fumes, weather, noise from riveting — D — 10

C EXPENSE: Clothes, gloves, shoes (tools furnished) — B — 0

H PHYSICAL EFFORT

TASKS PERFORMED	DEGREE %	TIME	POINTS
Test & inspect boilers; burn & weld	30	30	11
Install & repair boilers	50	10	6
Structural work	60	35	26
Layout	20	15	4
Wait, personal, etc.	0	10	0
			47

VII FATIGUE: MENTAL EFFORT 90 + SURROUNDINGS x 2, 50 = PHYSICAL EFFORT x 3, 141 = 424 x 139 x — 36

REMARKS

DESCRIBED BY
RATED BY USS Sub-committee for Job Evaluation
DATE 10-25-37

TOTAL POINTS 707

Courtesy Carnegie-Illinois Steel Corp.

FIG. 5 JOB DESCRIPTION AND EVALUATION SHEET

panies have the point system as those who have the ranking system, it is the opinion of the author that the point system is better than the ranking system, or the informal comparison to community rates. In his opinion, the point system has the following advantages:

1 It is more definite, more systematic, and more scientific.

2 It attempts to eliminate personal opinion and prejudices more than does either the ranking system or the informal system.

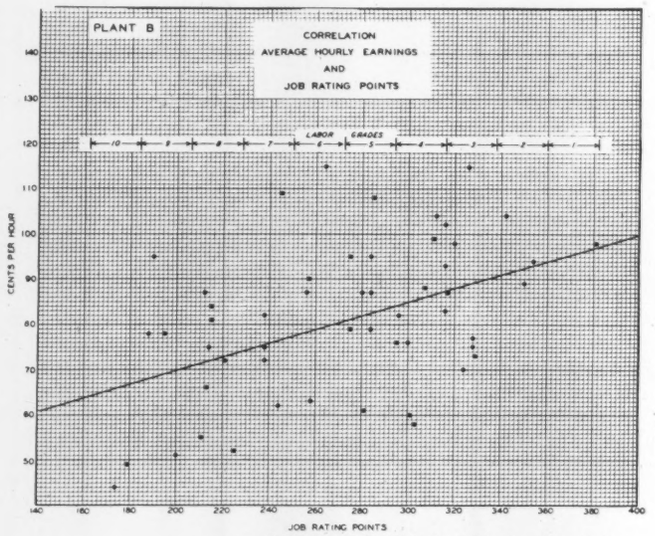
3 It is reasonable to expect that the sum of the judgments of the factors or elements of a job is more correct than the judgment of the job as a whole, as has been found true in time and motion study where the sum of the times of the therbligs or elements of a job has been found to be better than the over-all time.

4 It is easier to compare the existence of the same characteristics in widely dissimilar jobs than it is to compare those jobs as a whole.

5 It appears to decrease argument because agreements as to the value of the elements seem to be in closer accord than the agreements as to the rank of each job as a whole.

6 It tends to make the judgment factor in job evaluation less impersonal and more exact, because it is believed that the job analyst can judge each factor more impersonally and more definitely than he can judge the job as a whole.

These reasons for which the author favors the point system do not mean that he thinks the grading or ranking system of job evaluation is valueless because he knows that the ranking method has accomplished excellent results in some companies and is favored by a few unusually competent personnel directors of long experience. This study indicates, a preference for the



Courtesy National Metal Trades Association

FIG. 6 JOB RATING CHART

point system among the greater number of companies.

After reviewing the different methods of job evaluation and expressing a preference for the point system, the author believes that the following should be considered for the improvement of job evaluation in the future: (1) More extensive use of job-evaluation methods in a greater number of companies and more industries; (2) a greater standardization of the methods used by the different companies so that comparisons can be made between companies and between industries; (3) the factors or elements of the job should be made more objective in an attempt to obtain a numerical measurement, if such is possible, on the factors by which a job is evaluated; (4) the factors of the job be considered as accurately and minutely as the cost of the evaluation will permit; and (5) greater cooperation with employees or their representatives in evaluating jobs.

These considerations will require conferences and greater cooperation among companies and among employer associations, such as has been recently shown between the National Electrical Manufacturers Association and the Metal Trades Association, toward greater standardization of job-evaluation methods and values.

The minutia of job evaluation could be developed to the point where the cost of an evaluation would be greater than any possible additional benefit that could be derived from the evaluation, but management will see that this will not happen.

The unions, such as the Steel Workers Organizing Committee of Pittsburgh (14), are recommending to their locals the use of the point system for evaluating jobs. It would seem advisable, then, for the unions and management or the employers associations to cooperate so that the methods of evaluating jobs will be agreeable even before an agreement is established by collective bargaining. This should prevent many wage difficulties from occurring.

It seems certain that in the future both management and employees, either individually or collectively, are going to demand more scientific methods of evaluating jobs. If scientific methods of evaluation are applied, and the right wages are paid for each job, one of management's first needs in personnel and industrial relations will be supplied.

BIBLIOGRAPHY

1 "Wage and Salary Administration," American Rolling Mill Co., 1934.
2 "Gauging the Job's Worth," by E. J. Benge. *Industrial Relations*, Feb.-Mar., 1932.
3 "The Technique of Wage Negotiation and Adjustment," by W. F. Cook. American Management Association, Personnel Series, No. 30, 1937, pp. 8–16.
4 "Job Evaluation," and "Salary Evaluation," General Electric Co., 1938.
5 "Pointers on Pay Plans," by Edward N. Hay. *Personnel Journal*, vol. 17, no. 3, Sept., 1938, pp. 88–95.
6 "Salaries, Wages and Labor Relations," by J. O. Hopwood. Ronald Press, New York, 1937.
7 "An Occupational Rating Plan," Industrial Management Society. Chicago, 1937.
8 "Job Evaluation," by L. J. King. *S. A. M. Journal*, vol. 3, no. 3, May, 1938, pp. 93–98.
9 "Job Rating," National Electrical Manufacturers Association, *Industrial Relations Bulletin*, no. 43, Sept. 28, 1937.
10 "Job Rating," National Metal Trades Association, 1938.
11 "Wage Determination," by J. W. Riegel. Bureau of Industrial Relations, University of Michigan, 1937.
12 "Position Analysis and Classification," by E. B. Roberts. *Management Review*, vol. 24, no. 7, July, 1935.
13 "Procedure of the Job Analyst," The Pennsylvania Company.
14 "Production Problems," Research Department, Steel Workers Organizing Committee, Pittsburgh, Pa.
15 "Job Evaluation Manual," United States Steel Corporation, New York, 1937.
16 "Rating the Job and Man," by J. E. Walters. *Factory Management and Maintenance*, June, 1937, pp. 394–404.
"Modern Management," by J. E. Walters. John Wiley & Sons, New York, 1937.
17 "Job Evaluation," by D. W. Weed. American Management Association, Production Series, No. III, 1938, pp. 3–15.
18 "Industrial Relations Manual," Westinghouse Electric and Manufacturing Company, Aug. 1, 1936.

II—A Specific Application

BY A. W. BASS, JR.

ATLANTIC REFINING COMPANY, PHILADELPHIA, PA.

JOB EVALUATION is one of the newer tools of scientific management, and, like time study, production control, plant layout, and many others, it is evolutionary. Being evolutionary, its natural development is from the academic to the practical. To date there has been much written about the comparative advantages of different systems of job evaluation, and much controversy over the use of points, the use of various factors in evaluating jobs, the relative weighting of these factors, the expressing of degrees of value in objective rather than in general terms, and over many other academic aspects of the systems. Much of this discussion has been of great value, for there certainly have been as many and varying degrees of commendability in job-evaluation systems as there are degrees of value in jobs.

The details of applying job evaluation in any company will vary to some extent with the actual plan or system used. It is not the intention to discuss in this paper the details of comparative systems, or to give a case history of the specific application made at The Atlantic Refining Company, but rather to suggest in more general terms certain problems and considerations to be recognized in any installation, and to interpret some of these things in the light of the experience gained in the application at the author's company.

Speaking very generally, the following four requirements are felt to be vital to achieving a successful application of job evaluation:

1 A plan of job evaluation which has been carefully thought out in relation to the type of work involved, and the portion of the total wage scale to which it will be applied.

2 Intimate knowledge of all the facts relating to the jobs to be evaluated. This is possibly of first importance, for no job can be evaluated more accurately than the extent to which it is known and understood.

3 Confidence of management and personnel in the results obtained from the plan; its value from an industrial-relations standpoint is in direct relation to the acceptance given it.

4 Selection of qualified individuals to administer the plan.

While these four points are vital to the successful installation and maintenance of job evaluation, their acceptance obviously does not furnish the information needed for actually applying a program. They are mentioned and emphasized here solely

Contributed by the Management Division for presentation at the Annual Meeting, New York, N. Y., December 5–9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

because the subsequent machinery of administration will creak badly if any one has not been given serious attention at the start.

FUNCTIONS OF JOB EVALUATION

Before determining where job evaluation belongs on the organization chart, it is necessary to understand or reconsider just what job evaluation is expected to do, and this is, first, to furnish the machinery for more equitable distribution of wages paid, through a study of the relative difficulty and value of jobs; and second, to supply the basis for more intelligent arbitration of wage questions with employees. Since wages, along with hours and working conditions, constitute the heart of the industrial-relations problem, job evaluation is to this extent an industrial-relations responsibility. Of course, there are other indirect values that develop through the application of such work, such as, the education of supervisors in the functions of their own and other departments' activities; the uncovering of inefficient organization relationships, etc. These are not industrial-relations problems, yet the primary purposes of wage setting and the arbitration of wage questions belong to those actively handling this function of management.

In The Atlantic Refining Company, responsibility for the job-analysis work is centered in a chief job analyst who reports directly to the president. This is necessitated by two factors: First, there are two departments handling industrial relations, one reporting directly and one indirectly to the president; and second, as salaries are being established up to approximately $10,000 a year, and as they cross all organizational lines, it is desirable to have supervisory responsibility for the personnel actually engaged in establishing salary grades divorced from any individual department head. But even here, with the activity reporting to the president, responsibility for negotiating wage disagreements with employees rests with the industrial-relations department.

Regardless of from what branch of management job evaluation derives its authority, it is imperative that it be a centralized function for the entire company, for only in this manner can an equitable assignment of wages be achieved as among the various departments, and as between hourly paid and salaried jobs. Quite a few companies today are organized on a unit basis for the several product or operating divisions, in which the unit manager has directing responsibility for manufacture, sales, service, engineering, personnel, etc. In such cases, it is highly desirable that job evaluation be coordinated and directed by one central authority, or else the more important industrial-relations advantages accruing from such work will be appreciably reduced. For example, if a decentralized program of job evaluation is followed, in which different departments or plants of the company conduct their salary and wage setting independently, it is inevitable that inequities will appear as between the classifications or grades established for similar jobs or jobs of similar value in the different units.

This will not only constitute a source of potential wage controversy, but if the level of wages paid varies among these different departments, the issue may be greatly confused as to whether the employees' dissatisfaction lies with the wage level or the job grading. As between salaried and hourly jobs, it is again important that the proper relationship should exist. While the level of wages paid may be different, due to differences in privileges and market factors, the relative difficulty in value of jobs should still be recognized and reflected in proper direction and degree.

COST OF JOB EVALUATION

There is a rather common belief current among many companies interested in installing job evaluation, that once some system has been selected, it can be installed and maintained without the addition of any personnel, and at little or no expense. Unfortunately this is not true. Except in cases of quite small organizations where the number of jobs to be covered is relatively few, it is considered inadvisable to attempt the installation with existing personnel who are expected at the same time to carry on their regular task. Since the original installation requires time and undivided attention, the assignment of a full-time individual or staff to the work will, in the end, result in a much better, therefore much cheaper, installation. The cost of installation is naturally contingent upon the number of jobs to be included in the study, and the subsequent maintenance cost depends on whether the jobs, by reason of the nature of the industry, or of the specific company, are subject to frequent change. The Atlantic Refining Company, employing in the neighborhood of 12,000 employees, of whom 7000 are either covered by job evaluation or are in the process of being covered, employs a staff of eight analysts to maintain the system as applied to all hourly jobs and a large number of salaried jobs, and to extend the work to the salaried jobs not yet covered. The current cost amounts to about 0.1 per cent of the company's total pay roll, and this should drop appreciably when the installation is completed and the problem becomes one purely of maintenance.

The current cost to The Atlantic Refining Company is higher than it would need be in many other companies, for several reasons: First, since there are few jobs which are functionally identical, the ratio of number of jobs to total personnel is higher in the petroleum industry than in many others, or in other words, there are more jobs for the same number of employees; second, on the average the jobs are more complex than those found in other industries, which makes preparation of job descriptions and their rating more difficult; third, the cost per job of applying job evaluation becomes increasingly greater as it is extended up the wage scale, and in The Atlantic Refining Company it has been extended well toward its theoretical limit. The theoretical limit is the point beyond which the economies of supply and demand of necessity play a larger part in determining salaries than a pure comparison of relative difficulty

The reason for this cost, which may appear high to some goes back to what was mentioned earlier, that is, that job evaluation can be no more accurate than the knowledge possessed of the job involved. An accurate, successful application of job evaluation can only result from the thorough detailed knowledge of all the facts surrounding all jobs to be rated. Obtaining and recording these facts requires considerable time and the services of a fairly competent type of individual. Within reasonable limits of time, the quality of the final job will reflect the caliber of the personnel engaged.

DESCRIPTION OF SYSTEM USED

Briefly, the actual job-evaluation system in operation at The Atlantic Refining Company uses points which are applied to the measurement of five critical factors. These factors are:

1 Mental effort, which is a consideration, in terms of the job, of the intelligence and education required and of the application made of it.

2 Skill, a consideration of experience, knowledge, and manipulative skills needed, again qualified by the amount of use.

3 Physical effort, or a measure of the intensity and frequency of the physical application required.

4 Responsibility, or a measure of the moral load placed upon the incumbent as a result of the material, equipment, safety, etc., involved, the probability of error, and the possible consequences thereof.

5 Working conditions which are composed of all those

factors, such as hazard, disagreeableness, time of day working, etc., which tend to make one job more or less desirable than another.

The points used are the result of a breakdown of the hourly rate paid a certain number of carefully selected "key" jobs at the time of installation. The key jobs selected were common to several industries, well-known, well-defined, and were in the opinion of both management and men, correct in comparison to the prevailing market, and equitable in relation to each other. In order to arrive at the relative weighting of these points for the five critical factors of measurement, the selected key jobs were given to a group of ten people, composed of four heads of operating divisions, the director of plant personnel, and five of the staff responsible for establishing the plan. This group was requested to study the descriptions and requirements of these jobs, and assign that portion of the total hourly rate to each critical factor which, in their opinion, represented the contribution of that factor to the total value of the job. This was done several times with sufficient time intervening to permit forgetting the ratings originally made. The total of the individual ratings secured was then analyzed by accepted statistical methods and the results, after eliminating obvious inaccuracies, were set up as anchor points, or the basic skeleton of a point-rating scale, to which all other jobs to be rated would subsequently be compared.

DESCRIPTION OF JOBS

From the standpoint of any program of wage and salary administration, no job exists until it is defined, for without definition it lacks concept. In order to have universal understanding and appreciation of this concept, the definition is not sufficient without being recorded, and it is in the job specification or job description that this record is made of the facts, functions, and conditions which go to make up the job.

When jobs are defined and recorded for purposes of job evaluation, it is well to provide on the same form for definition and analysis of those facts, conditions, or requirements which relate to the critical factors forming the basis of the job evaluation. In other words, if the evaluation is made on the basis of education, intelligence, experience, etc., required by an individual to handle the job, provision should be made for recording these facts on the same form with the job definition, even though they do not form a part of the actual definition of the function and duties of the job itself. The finished job specification therefore serves a dual purpose, first as a means of defining and recording the facts relating to the functions and responsibility of the job itself, and on the other, of defining and recording those requirements relating to the factors used in the evaluation.

Too much emphasis cannot be placed upon the importance of accurate, complete, and intelligible job descriptions. They are important, in the first place, in order that accurate ratings result from the installation; in the second place, in order that subsequent changes in jobs can be recognized and reflected in changed rating; thirdly, in selling the plan to employees, for they will have much greater confidence in the accuracy and impartiality of the rating if they see in the job description, a true and complete picture of the work they do.

Obviously, before any job description can be prepared, it is necessary to become familiar with the job itself. There are several ways of getting this information. The policy of The Atlantic Refining Company has been to secure it from the employees themselves. There is a dual advantage in doing this, first probably no one else knows as much about a job as the man actually doing it; and second, it is good industrial-relations policy to make the individual a part of any program affecting him as intimately as does the setting of the rate or range of rates from which he will be paid. There is a choice of two methods to follow in getting the information, the one is by questionnaire, and the other by personal interview.

The value of the questionnaire in obtaining information on hourly jobs is too slight to justify its use. A few hourly employees cannot write, and a larger number have not sufficient clerical aptitude to give an intelligible written picture of what they do. Moreover, the general functions, the duties, and the required skills of most hourly jobs are both relatively obvious and commonly known.

To interview personally most of the hourly employees in a company of any size is necessarily a large undertaking. An obvious short cut would be to interview the various foremen and supervisors, obtain from them an outline of what jobs there are and a definition of the duties, skills, and requirements involved in their performance. However, it is very probable that this will not afford entirely satisfactory results because in the first place, all foremen do not possess the same concept of what constitutes a job; in the second place, foremen do not always have equal knowledge of the jobs they are supervising and their definitions can easily be colored by how much or how little they know; and thirdly, the foreman may be subjected to accusations, whether justified or not, of favoritism.

With respect to salary jobs, questionnaires are of value, and their use can be justified, though not as a substitute for personal interviews. Experience has indicated that the latter is the only fully satisfactory method for developing the facts necessary to the preparation of an accurate and comprehensive job description. It is logical that this should be the case, for to assume that the individual employee can fill out any sort of questionnaire so comprehensively, in such detail, without taint of prejudice, and with properly placed emphasis, as to permit preparation of adequate job descriptions, is to assume that every employee is capable of preparing adequate job descriptions. The questionnaire prepared by individual employees at The Atlantic Refining Company serves in three different ways: First, as an introduction to the work since prior to the interview the duties and responsibilities claimed by the individual are studied, notes are made of points needing further explanation, and a general picture is sketched, which saves considerable time in making the subsequent interview; second, as the source of employee opinions regarding the educational, skill, and other requirements of the job which form the basis for ultimate point ratings; third, as a record of the employee's concept of the job at the time of rating.

The individual questionnaire, and the interview have been augmented in this application with the supervisor's questionnaire. On this it has not been felt necessary to have the supervisor fill in the description of the duties performed, as this in general is adequately covered by the individual form and the interview. The supervisor, rather, is asked for his estimate of the required learning time and experience, and his opinion on other matters which involve questions of opinion rather than of fact. These opinions, together with those of the individual are referred to and weighed by the analyst in establishing the job requirements which are recorded on the completed job specification form. In addition, the supervisors' questionnaire serves one other purpose. As only one form is filled out for each job, with the names of the several incumbents, it serves as a preliminary guide to but not a criterion of what jobs, as such, exist.

POINT-RATING PLAN

The actual point ratings used at The Atlantic Refining Company for evaluating salaried jobs are nothing more than an extension of the hourly point scale, for here, as in most installa-

tions, the hourly jobs were done first. Furthermore, the salary scale used is basically a modified extension of the hourly wage scale. It is not obligatory that job-evaluation systems based on points employ a common point scale in the case of both hourly and salaried job evaluations, or that the two wage scales possess the same slope and the same absolute value per point. The former is desirable, however, in that it permits more readily the comparison of wages paid jobs of the same difficulty, but paid on the different bases. The latter is mainly a question for top management to decide; that is, how much the additional privileges of a salaried position are worth in terms of wages, and what the existing market rates for the various types of salary jobs are.

While in the case of the author's company the basic point scale is common to both hourly and salaried job evaluations, and the basic level of wages is approximately the same, the actual division of the wage scale into grades or classifications differs. In the case of hourly jobs, the point scale was divided into point classes of three point increments, for example: 87, 88, or 89 points, and any job whose point rating fell within this range, was paid a rate corresponding to the median figure, of 88. As mentioned before, for convenience these points were originally cents per hour. However, it was recognized that future wage adjustments would make them purely abstract points, and so now a conversion factor is applied to secure the equivalent contemporary rate.

The establishment of three point intervals with their equivalent hourly rate as grades or classifications, rather than five point intervals, or none at all, was purely a matter of judgment as to what best suited the conditions. To require that any system of job evaluation establish and defend differences of one cent per hour in the rating of separate jobs, gives the appearance of undue optimism. Conversely, to admit appreciable differences in the rating of jobs and not be able to recognize them in the hourly rate tends to defeat the fundamental purpose of the work. The three point intervals constituted the most logical compromise.

Unless affected by temporary, extraneous conditions either within the company or within the competitive labor market, any curve of salaries drawn against dollars and relative difficulty, should be a straight line. In other words each unit of difficulty should be represented by an absolutely equal unit of salary. Further, the per cent difference between minimum and maximum salary for any classification, superimposed on this salary scale, should be constant at all points on the scale. In other words, the same per cent difference should obtain for those jobs at the bottom as for those at the top. These statements are made not so much perhaps on the basis of any positive logic in their favor, as from the lack of any positive arguments to disprove them, and the fact that past practice and the experience of most companies bears them out. These principles found concrete application in the case of The Atlantic Refining Company salary scale.

Those jobs which justify payment on a salary rather than an hourly basis are, among other things, jobs in which different incumbents, functioning acceptably on the job, can still be worth markedly different amounts to the Company. This, in addition to the fact that precedent has established greater permanency to the wages of salaried as opposed to hourly rated employees, necessitates a more flexible means of administering salaries to employees in this category. In order to achieve this greater flexibility without sacrificing the goal of reflecting in salary recognizable differences in job values obligates the adoption of overlapping salary grades. Two problems are created by this: First, the selection of the percentage increase in difficulty from one class to the next, or expressed in another manner, the number of class or grade divisions to be made of the total scale; and second, the selection of the percentage spread desired between minima and maxima of the grades. The percentage selected in both cases can represent nothing more than pure judgment and results of past experience as to what seems best to apply. In our own case the percentage increment of points from grade to grade was established at approximately 12 per cent, and the percentage range between maxima and minima within the grade at 33 per cent.

APPROVAL OF ESTABLISHED GRADES

With all the machinery set up for securing the facts about the job, for preparing the job specification, and finally for establishing the hourly or salary grade to be applied, it is still necessary to provide machinery for executive approval of the established grade, and for the arbitration of any deadlocks arising between the analyst and department heads.

This probably constitutes one of the ideal subjects for committee action, for in applications in which the analysis crosses all organization lines and extends well up the salary scale, the executive head of the company might be the only individual in a position of sufficient authority and sufficiently detached from prejudice, to make decisions acceptable to the various functional heads, and even then from a practical standpoint he is too far removed from the bulk of jobs rated to be able to make such decisions on the basis of knowledge.

Of course, the make-up of any committee selected for this purpose, and the determination of from whom it receives its authority is contingent upon what, if any, major organization lines are crossed by the study, and upon how far up the wage scale the evaluation is applied. In general, the committee should be appointed by, and receive its authority from, the responsible head of all divisions and departments represented in the study. If all departments in a company are represented, the authority should stem from the president, while if only jobs in the manufacturing organization are represented, authority can very well stem from the manufacturing head.

A committee established in this manner can function very effectively for two reasons. First, it carries the prestige and authority necessary to make decisions as between analyst and department head, and as among different departments. Second, if composed of individuals with experience in all phases of the work coming before it, it supplies a well-balanced group judgment, which will tend to reduce any possibility of aggressive department heads gradually raising rates in their departments to a level disproportionate to those of other departments.

MAINTENANCE OF SYSTEM

No installation of job evaluation is complete until some provision has been made for its maintenance. This can be handled by the same organization doing the original work, and can be audited by the same committee. Theoretically, it is possible to set up such controls in the time or pay-roll department, and so educate the supervision of the various departments, that new or changed jobs are to be immediately called to the attention of the group responsible for the analysis. Actually this does not work well in practice, for jobs are modified, and new jobs created without notification being given the proper authority. It has been found desirable in many applications, therefore, to have the job analyst make a personal recheck of the contents of all jobs annually. This again may appear as an expensive proceeding and one which could be obviated. Actually its cost is but a fraction of the cost of the original installation, and without adequate provision for maintenance, the advantages of equitable administration of wages for which job evaluation was adopted will in time tend to disappear.

HARD-SURFACING PROCESSES *and* MATERIALS

By M. L. BEGEMAN

THE UNIVERSITY OF TEXAS

HARD surfacing is the process of applying to a wearing surface some metal or treatment which renders the surface highly resistant to abrasion. Such processes vary a great deal in their technique; some apply a hard surface coating by fusion welding, while in others no material is added and the surface metal is changed by heat-treatment or by contact with other materials. Along with the development of the processes there have also been developed many new hard-surfacing materials.

There are several properties required of materials subjected to severe wearing conditions. Important among these are hardness, abrasion resistance, and impact resistance. Hardness is easily determined by several known methods and an accurate comparison of metals for this property may be obtained readily. Tests for wear or abrasion resistance have not been standardized and for this property it is difficult to obtain comparative results. Considering all the factors involved, hardness is probably the best criterion of wear resistance. Ability to withstand wear and abrasion usually increases as the hardness of the metal increases.

In many cases extreme wear occurs because of a combination of friction and impact or by impact alone. This necessitates some knowledge of the relative impact resistance of the metals being considered. Numerous testing machines have been developed for determining some sort of an index of impact resistance, most of them being the pendulum type of machine. Such tests are satisfactory for obtaining relative results where suitable test specimens may be obtained, but are hardly suitable for testing thin coatings applied to another metal of a different analysis. The process of applying a hard surface coating may change its properties slightly. Internal strains set up in the surface may also increase the tendency of the metal to crack when subjected to impact. Such conditions make it difficult to obtain comparative results by known testing methods and necessitate falling back on actual tests under service conditions. When impact is a severe factor, a certain amount of hardness and wear resistance must be sacrificed and this factor must be considered in selecting materials and processes.

When impact is associated with abrasion, a measure of the surface hardness does not give a true index as to the rapidity of wear. When the surface structure is uniformly hard there is apt to be accelerated wear due to the brittleness of the coating which results in chipping or spalling when subjected to impact. In such cases it is necessary to associate the hard constituent with a softer material to withstand this action. This matrix, through which the hard particles are dispersed, should have strength and toughness and be as hard as possible consistent with the type of service that will be imposed upon it. Such structure may be controlled readily by proper selection of the rod material in fusion-weld deposits.

Contributed by the Iron and Steel Division for presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, December 5–9, 1938, New York, N. Y.

In addition to the properties just mentioned there are cases where the ability to operate at high temperatures is important. In such cases alloys containing chromium, tungsten, molybdenum, and other known heat-resisting elements should be considered. Cutting tools are naturally thought of as being one of the principal hard-surfacing applications where "red-hardness" ability is desired. It is true, however, that considerable heat is generated by severe frictional contact and, while there is no visual evidence of the heat, the wear resistance is reduced by the softening of the particles under heat that are in contact with one another.

Some consideration should be given to melting points and coefficients of expansion in cases where dissimilar metals are bonded together. From the standpoint of applying the metal, it is desirable to have the melting point of the surface metal slightly lower than that of the parent metal. The coefficients of expansion of the two should be as nearly the same as possible to eliminate a tendency to spall when subjected to a rapid change of temperature.

Little work has been done in regard to determining the tensile and shearing properties of hard-surfacing materials as it is usually considered that such materials are not stressed appreciably in that manner. However, such tests would give a good index as to the binding qualities of different surfacing materials and would also enable a wiser choice of parent materials, especially if tests were made after the materials were bonded.

Corrosion resistance is not of prime importance in cases where severe wear has to be overcome. It is a desirable property that is found in many of the hard-surfacing materials; and in a few cases, in dealing with corrosive materials, it becomes an important factor.

CARBURIZING

The oldest known method of producing a hard surface on steel is by case hardening or carburizing. This process in brief is merely heating iron or steel to a red heat in contact with some carbonaceous material. Iron at temperatures close to and above its critical temperature, that is 1550 to 1750 F, has an affinity for carbon. The carbon enters the metal to form a solid solution with iron; hence, the necessity for the high temperature. The process is the same as the old cementation process for making steel except that it is stopped before the carbon penetrates very far into the interior of the metal.

This method is ideal for machine parts which are subjected to hard wear and impact. The steel used for this process is usually a low-carbon steel of about 0.15 C which does not respond appreciably to heat-treatment. In the course of the process the outer layer is converted into a high-carbon steel with a carbon content ranging from 0.9 C to 1.2 C, with the carbon content gradually decreasing toward the interior. By proper heat-treatment such steel will have an extremely hard surface on the outside and a soft ductile center.

It has been found that certain alloys in a low-carbon steel

greatly improve the qualities of the final product. Nickel is frequently used in percentages from 2 to 4 per cent as it improves the strength of the steel, reduces the brittleness some, and promotes a fine grain structure. Chromium increases the hardness appreciably and gives a small grain structure. The percentage of chromium ranges from 0.50 to 1.50 in such steel, and in some cases is alloyed to advantage with molybdenum. Aside from the improved qualities obtained in the case, these alloys also give a stronger and tougher core.

The average rate of penetration is around $\frac{1}{8}$ in. in 24 hours; however, the depth of penetration is affected by several factors. Important among these is the temperature at which the process takes place. For reasons mentioned previously this temperature is usually around 1650 F. Higher temperatures shorten the time required for a given depth, but have the bad effect of promoting excessive grain growth. It is also advisable to sacrifice some temperature to prevent rapid deterioration of container and furnace.

There are many different carburizing reagents used and these may be classified as solid, liquid, and gaseous materials. In the first group any form of highly carbonaceous material is suitable. Among those used are bone dust, charred leather, charcoal, charcoal and barium carbonate, lampblack, coke dust, anthracite, and numerous other commercial mixtures. Any solid reagent to be successful should evolve gases during heating. These gases, chiefly CO and CH_4, are the principal carburizing agents in the process. Those which fall in the second group are such salts as potassium cyanide and ferrocyanide of potash that form a liquid solution when heated to a carburizing temperature. Cyanide salts act more rapidly than other materials although their deterioration is quite rapid. The presence of nitrogen seems to assist in the penetration of carbon into the steel and also contributes materially to the hardness of the core. The time is quite short in this process, usually ranging from 5 to 30 minutes. Consequently, only a thin core of several thousandths of an inch is obtained. Its main use is in the hard surfacing of small pieces. The principal gaseous reagents are CO, natural gas, city gas, and acetylene. This application is sometimes used in the surface hardening of gear teeth and other parts using an acetylene welding torch with a reducing flame.

The final properties of carburized materials are determined by heat-treatment. There are several procedures, the simplest being to quench from the carburizing temperature. Water quenching is usually employed for carbon steels, while oil quenching is used for alloy steels and frequently this operation is followed by a low-temperature draw to relieve strains and case brittleness. This method of heat-treating is suitable only for parts not subject to severe shock. For improved physical properties to resist shock, a double heat-treatment is recommended. After cooling, the steel is reheated to a temperature just above the critical range of the core and quenched. This treatment refines the grain size of the core, but still leaves the case with an excessive-size grain structure. The steel is then reheated once more to a temperature just above the critical temperature of the case and quenched a second time. This operation, occurring at a lower temperature than the first, refines the case and gives it the required hardness. A low-drawing operation may be used to relieve internal strains.

Pieces ranging in size from armor plate to ball bearings may be successfully case hardened. The hardness obtained is limited to that of a martensitic steel, around 750 Brinell maximum.

NITRIDING

Nitriding is somewhat similar to ordinary case hardening, but uses a different material and treatment to create the hard-surface constituents. In this process the metal is heated to a temperature around 950 F and held there for a period of time in contact with ammonia gas. Nitrogen from the gas is introduced into the steel forming very hard nitrides which are finely dispersed through the surface metal.

It has been found that nitrogen has greater effectiveness with certain elements than others; hence, special nitriding alloy steels have been developed. Aluminum in percentages of from 1 to 1.5 has proved to be especially suitable in steel as it combines with the gas to form a very stable and hard constituent. Chromium and molybdenum are important elements in such steels, accomplishing similar results; in addition, vanadium, manganese, and tungsten may also be used effectively.

The temperature of heating ranges from 850 to 1200 F although 900 to 950 F is the temperature range generally used. Higher temperatures will increase the depth of a case for a given period of time, but such treatment does not give as hard a case as when heated in the lower range. The hardest part of the case is just under the surface with a gradual tapering off until the core hardness is reached. The total effect of the treatment extends in from the surface about 0.020 in. after a 48-hour treatment at 975 F. The case thickness depends upon the temperature, time, and nature of the steel being treated.

One of the advantages of this process is the extreme hardness developed in the surface of the steel and its ability to resist wear. This hardness ranges from 900 to 1100 Brinell, which is considerably higher than that obtained by ordinary case hardening. Nitriding steels by virtue of their alloying content are stronger than ordinary steels and respond readily to heat-treatment. It is recommended that these steels be machined and heat-treated before nitriding as there is no scale or further work after this process. Best results are obtained when the work has been given a proper grain-refining treatment before the process. A sorbitic structure in the core is to be desired because of its inherent toughness and ability to withstand heavy loads and impact. Fortunately the structure and properties are not affected appreciably by the nitriding treatment, and since no quenching is necessary, there is little tendency to warp, develop cracks, or change its condition in any way. The surface effectively resists corrosive action of water, salt-water spray, alkalies, crude oil, and natural gas.

Many automotive, airplane, and Diesel-engine wearing parts are treated by this process as well as numerous miscellaneous parts such as pump shafts, gages, drawing dies, gears, clutches, and mandrels. Its use is limited by the time and expense.

CHAPMANIZING

The chapmanizing process[1] is also based on the fact that ferrous metals will absorb nitrogen and carbon to form a hard compound when heated to high temperatures. While the results of this process are somewhat similar to nitriding, they are accomplished in a different manner. In this process the metal is heated in a liquid bath to around 1500 F. An active nitrogen gas is introduced into this liquid from which the nitrogen is absorbed by the steel. The length of time required depends on the case thickness desired, but compared to most other processes it is quite rapid. Usual case depths vary from 0.003 to 0.030 in. and the time ranges from a few minutes to 3 hours. Rather special equipment is required for processing and introducing the ammonia gas into the bath, but no special furnace is required. Any standard pot-type furnace is satisfactory.

It is claimed that this process is more rapid than most case-hardening processes and does not require special-analysis steel for successful results. A very hard case is obtained ranging

[1] Developed by The Chapman Engineering Corporation.

from 700 to 1100 monotron Brinell which is about the same hardness as obtained by nitriding. There is some variation in the hardness, depending on how the steel is quenched and the type of steel used. The hardest portion of the case is about 0.003 in. under the surface.

DRY CYANIDING

"Dry Cyaniding"[2] is the name given to a process of continuous gas carburizing and nitriding developed for surface hardening of steels. The operation is carried out in a continuous muffle furnace; the carburizing gas is introduced at the charging end and the ammonia gas is introduced at the point where the parts to be treated have come up to the desired temperature. A thin film of amorphous carbon is formed on the objects being carburized, which reacts with the ammonia at the high temperature to form a hydrocyanic-acid gas. This gas has proved to be a very effective cementation reagent and when produced in this manner there is little hazard attending its use. A variety of carburizing gases may be used.

A variety of S.A.E. steels have been used in this process at temperatures ranging from 1150 to 1550 F. The final hardness is obtained by oil quenching and the hardness value according to the Rockwell C scale ranges from 50 to 65. The case depth for a treatment of about 2 hours is approximately 0.010 in., and the constituents vary according to the amount and kind of gases used.

NI-CARB PROCESS

The Ni-Carb method[3] is very similar to the dry-cyaniding process, utilizing both ammonia gas and a carburizing gas. Any carbon-rich gas such as natural gas, propane, or most city gases can be used. The process is adapted to either a retort or a continuous muffle furnace.

The temperature employed may be varied from 1200 to 1600 F. It is selected according to the depth and characteristic of the case desired and the kind of steel being heated. The case forms quite rapidly; from 27 to 45 min. in the actual heat produces depths from 0.002 to 0.001 in. The final hardness is obtained by water or oil quenching and is approximately the same as a cyanided case.

This process is intended primarily for thin cases. Most grade steels may be treated by this process as well as steel castings, cast iron, and malleable iron.

INDUCTION HARDENING

The heating and melting of metals by induced electric currents has had practical application for some time. It is only recently, however, that this means of heating has been employed in surface hardening. The process here described is commonly known as the Tocco process[4] and was developed for the principal purpose of surface hardening crankshaft bearings and other similar wearing surfaces. It differs from ordinary case-hardening practice in that the analysis of the surface steel is not changed, the hardening being accomplished by an extremely rapid heating and quenching of the wearing surface which has no effect on the interior core metal. A surface hardness of around 58 to 62 Rockwell C is obtained.

An inductor block acting as a primary coil of a transformer is placed around, but not touching, the journal to be hardened. A high-frequency current, usually 2000 cycles, is passed through this block, inducing a current in the surface of the bearing. The heating effect is due to induced eddy currents and hysteresis losses in the surface material. As the steel is heated to the upper critical range, the heating effect of these losses is gradually decreased, thereby eliminating greatly any possibility of overheating the steel. The inductor block surrounding the heated surface has water connections and numerous small holes in its inside surface. As soon as the steel has been brought up to the proper temperature it is automatically spray-quenched under pressure.

An important feature of this method of hardening is its rapidity of action, since it requires only 5 sec to heat the steel to a depth of $^1/_8$ in. Another advantage is that only a small percentage of the weight of the object to be treated is heated to the necessary high temperature. Obviously, this procedure eliminates warping to a great extent and consequently necessitates only a small allowance for grinding to finished size. The local heating does not affect any previous treatment given to the core or cause trouble at fillets. Medium-carbon steel has proved very satisfactory for parts treated in this manner and the nature of the process has partially eliminated the necessity of using costly alloy steels.

FLAME HARDENING

Flame hardening, like the induction-hardening process, is based on rapid heating and quenching of the wearing surface. The heating is accomplished by means of an oxyacetylene flame which is applied a sufficient length of time to heat the surface above the critical temperature of the steel. Integral with the flame head are water connections which cool the surface by spraying as soon as the desired temperature is reached. By proper control the interior surface is not affected by the treatment, the depth of case being a function of the heating time and flame temperature.

There are several methods employed in this process. In stationary or spot hardening, both torch and work are stationary and the effect is local. Progressive hardening refers to cases where the flame and work move with respect to one another, as in the case of rail hardening. As the flame progresses the work is immediately quenched behind the flame. Spinning or rapidly rotating circular work may also be used employing one or more flames. This method is usually applied to fairly small work when the heating time is short. The quenching is done while the work rotates. Spinning may also be used in connection with a progressive movement of the torch along the side of the work. Hand operation is not recommended as it does not produce uniform results.

The following advantages are claimed for this process: Hard surfaces with a ductile backing may be obtained, large pieces may be treated without heating the entire part, the case depth is easily controlled, the surface is free of scale, and the equipment is portable. This process may be used on most of the commonly used steels. The surface hardness will depend on the percentage of carbon and the alloying elements present. Average values will vary from 350 to 650 Brinell.

METAL SPRAYING

The spraying of molten metal is a comparatively recent development and is rapidly becoming an important process in industry. Any metal obtainable in wire form can be applied in this manner. The wire is fed into the spray gun at a definite rate where it is melted by an oxyacetylene flame and then blown by compressed air to the surface being coated. Another type of gun, developed in England, has a heated container into which molten metal is poured at intervals, but otherwise acts in the same manner.

It is important in this process that the surface of the metal be properly prepared before spraying, because the bond be-

[2] Developed by The Surface Combustion Engineering Corporation.
[3] Developed by the American Gas Furnace Company.
[4] Developed by The Ohio Crankshaft Company.

tween the sprayed metal and the parent metal is entirely mechanical. The usual method of cleaning and preparing the surface is by blasting with sharp silica sand or angular steel grit. Cylindrical objects may be prepared by rough turning on a lathe.

Either of these methods roughen the surface and provide the necessary interlocking surfaces or keys so that the plastic metal will adhere to the surface. The molten metal is blown with considerable force against the surface causing it to flatten out and interlock with the surface irregularities and the adjacent metal particles. The sprayed metal itself provides a suitable surface for successive coatings and permits building up a layer of considerable thickness.

Obviously, there is some change in the physical properties of metal applied in this manner. There is an increase in porosity and a corresponding decrease in the tensile strength of the material. This is due to the bond being mechanical and not a fusion as obtained by welding. The compressive strength is high and suitable for most purposes. Brittleness increases as does the hardness. Stainless steel and high carbon deposits will develop a Scleroscope hardness of from 70 to 75 which corresponds to a Brinell hardness of 500 to 550. The wearing quality of sprayed metal is good as evidenced by its wide use in building up worn shafts and other machine parts. All deposits can be finished satisfactorily by usual machining or grinding methods. In general, the metals retain enough of their original properties for protection purposes, for corrosion prevention, and for restoring worn surfaces.

Corrosion prevention constitutes one of the main applications of this process and for this purpose zinc, cadmium, lead, and aluminum are the principal metals used. It is frequently claimed that metals applied by this method have greater resisting properties than if applied by plating, due to the fact that the coatings may be thicker and there is no trace of acids at their base.

Aside from building up worn surfaces, which is another important application, it is possible to apply sprayed coatings to effect hard wearing surfaces. There are two types of stainless steel in general use, the ordinary 18–8 and a special air-hardening steel. This latter steel gives the maximum surface hardness obtained by this process. Sprayed metal being air-quenched is naturally harder than the original metal and has proved very satisfactory for wearing surfaces.

The success of this process is due largely to its economy and the rapidity with which the metal can be applied. There is no distortion in the parts being surfaced nor are there any internal stresses developed by the process. Its field of application is large since practically any metal can be applied to any other commercial metal and to other base surfaces such as wood and glass.

METAL PLATING

Electroplating has long served as a means for applying decorative and protective coatings on metals.

For wear or abrasive resistance, the outstanding metal for plating metallic surfaces is chromium. For this duty, coatings are seldom less than 0.002 in. thick, and may be considerably more. Coatings of this nature are not plated on a soft base metal but directly onto the hard parent metal. If plated on a soft base metal as copper or nickel it will have greater corrosion-resisting power but its resistance to abrasion and deformation will be much less. Hence, any measure of hardness or abrasive resistance is to some extent a function of the metal upon which it is plated as well as the chromium deposit itself.

The process is electrolytic and consists in passing an electric current from an anode to a cathode, the cathode being the object upon which the metal is deposited, through a suitable chromium-carrying electrolytic solution in the presence of a catalyst. The catalyst does not enter into the electrochemical decomposition. The electrolyte is a solution of chromic acid with a high degree of saturation. The surfaces must be thoroughly polished and cleaned before operations start. Since the rate of deposition is fairly slow, the work must remain in the tanks several hours for heavy plating.

Chromium has proved very satisfactory for wear-resisting parts because of its extreme hardness. According to the Brinell scale the hardness of plated chromium ranges from 500 to 900. This wide variation is not due to the metal but to methods used or inadequate equipment.

FUSION-WELDING PROCESSES

Where thick coatings of materials are required it is necessary to use some form of welding. The electric-arc process is both simple and economical in its operation and for most ferrous alloy materials it is very suitable. The acetylene process operates at a lower temperature than an electric arc and can be controlled more readily where excessive puddling of the material is not desirable. A certain amount of penetration or bonding is necessary when applying hard facing materials, but in general it should be kept at a minimum so as not to dilute the weld metal with the parent metal.

The hard facing materials are roughly classified as "overlay" and "diamond substitute" types. The overlay materials include such metals as high-carbon steel, ferrous alloys that include such elements as chromium and manganese, and numerous nonferrous alloys containing principally cobalt, manganese, and tungsten. The hardness of these materials varies considerably, ranging from around Rockwell 40 C to 70 C. According to the Moh scale the hardness seldom exceeds 8. The "diamond substitutes" are such materials as tungsten, boron and tantalum carbides, and chromium boride. These materials are among the hardest that are available and on the Moh scale fall between 8.5 and 9.5. They cannot be applied by self-fusion but must be bonded to the parent metal with some lower-melting alloy. They are prepared commercially in the form of small inserts of various shapes or they can be obtained in a crushed state, graded according to screen size. The crushed material may be fused with some binding material into rods or put in small steel tubes mixed with a certain percentage of granular metallic binding material. This application is quite similar to oxyacetylene welding with solid rods. When applied on oil-well drilling bits, the surface to be covered is frequently first coated with a gelatin-like material which holds the granular particles in place as they are sprinkled over the surface. They are then fused to the parent metal with an oxyacetylene torch.

High-carbon welding rod with a carbon content ranging from 0.9 to 1.1 is the most economical hard-facing material to apply from the standpoint of initial cost. Such rods may be applied equally well by either the electric-arc or oxyacetylene method of welding. They form a tough surface of moderate hardness ranging from Rockwell 30 C to 45 C. The hardest surface is obtained by rapid quenching and, as is the case with all martensitic deposits, not much additional hardness can be obtained by cold working. Their corrosion resistance is poor but such coatings have a wide application where wear resistance is desired.

Increased hardness and wear resistance can be obtained by alloying steel with such elements as nickel, manganese, molybdenum, and chromium. The limit of hardness for such coatings is around Rockwell 55 C. Since many of the alloys result in austenitic deposits, their hardness can be increased by cold

working. Corrosion resistance of most of these materials is good as is their resistance to impact, and no heat-treatment is required after application.

In the nonferrous group are included all rods the composition of which is made up of elements other than iron, although in many cases small percentages of iron may be found. The principal elements in this group are tungsten, chromium, molybdenum, and cobalt. The average room-temperature hardness of this group is about the same as for the ferrous-alloy group. Their advantage is that a high percentage of this hardness is retained while at red heat, which adds greatly to their wear-resisting power. In severe abrasive work considerable heat is developed by friction which acts on the minute areas of particles in contact. The effect of this heat is to soften the metal on these areas and cause them to wear away. However, if the metal in contact can retain a hardness at a relatively high temperature, it has a much greater resisting power to wear than metals that do not have this property. In such cases the initial hardness is not a true criterion of the wear-resisting ability of the metal.

Both the electric-arc and oxyacetylene process can be used in applying this material, the latter process being preferred. Better control of the deposit is obtained and there is less dilution of the rod with the parent metal. There is also no loss of the expensive rod material by volatilization and spattering. Practically any carbon or alloy steel can be hard-surfaced with this material and it is especially adapted for coating surfaces subject to severe abrasion and impact.

DIAMOND SUBSTITUTES

The so-called "diamond substitutes" constitute the hardest materials that are available for hard surfacing. These materials are generally spoken of as cemented carbides and include tungsten carbide, tantalum carbide, titanium carbide, boron carbide, and chromium boride or a combination of these and other carbides with a suitable cementing agent. In the case of tungsten carbide, which is one of the most common of this group, the usual analysis by percentage is tungsten 81.4, cobalt 12.7, carbon 5.3, and iron 0.6. The cobalt serves as a binder and adds to the ductility of the carbide. It may vary in percentage from 5 to 13. Tantalum carbide is 87 per cent Ta C with 13 per cent of some binder. The binder usually is either a combination of molybdenum and iron, or tungsten carbide and cobalt. Boron carbide contains about 78.2 per cent boron and 21 per cent carbon with a small trace of silicon and iron. It is usually known by the symbol B_4C. Many similar carbide materials are manufactured under special trade names, the compositions of which are not generally known and vary with manufacture.

This material cannot be applied as other hard-surfacing materials because of its high melting temperature. It is either furnished in the form of small inserts or in screen sizes. The inserts are frequently applied by a brazing or sweating-on process. In other cases the insert is placed in melted or puddled metal and then surrounded by metal from a steel or hard-surfacing welding rod. Screen sizes of crushed carbide particles can be applied conveniently by putting the particles in steel tubes. The steel sheath melts like an ordinary welding rod and fuses to the metal. The carbide particles do not melt but are distributed through the molten metal and are held fast when the metal cools. Screen sizes can also be applied by mixing the particles with a suitable binder and casting them into rods. These rods can be used conveniently like other hard-surface welding rods.

These materials all have a hardness approaching that of a diamond and on the Moh scale it ranges from 9 to 9.5. This hardness is maintained to a large extent at a red heat. Due to its extreme hardness and brittleness it does not have a high strength rating and is not suitable where severe shock and impact conditions exist. This difficulty is partially eliminated by properly supporting the elements with a tough binding material. Another characteristic of this surfacing material is that it does not respond to heat-treatment or cold working and retains its initial hardness under all conditions. It is not suitable for casting although a few hard materials, principally boron alloys with an iron base, can be processed in this manner.

Cemented carbides have a wide application in industry. They are used principally for cutting-tool material and for parts subjected to extreme wearing conditions. Tools that are tipped with such inserts greatly outlast any other form of cutting tool.

BIBLIOGRAPHY

1 "The Wear of Metals," by L. Jordan, MECHANICAL ENGINEERING, vol. 53, 1931, p. 644.

2 "Relative Wear of Metals Due to Abrasion," by C. R. Weiss, unpublished paper No. 62, A.S.M.E., May 4, 1932.

3 "Overlays Vs. Castings of Wear-Resisting Alloys," by M. C. Smith, *American Machinist*, vol. 81, May 19, 1937, p. 415.

4 "Boron Carbide," by K. R. Ridgway, Transactions of the Electrochemical Society, vol. 66, 1934, p. 117.

5 "Hard Facing Materials and Methods," by R. E. Brown, *Metal Progress*, vol. 28, no. 4, October, 1935, p. 136.

6 "Summarizing Sintered Carbides," by F. W. Curtis, *Metal Progress*, April, 1936.

7 "Hardness Values for Electrochemical Products," by K. R. Ridgway, A. H. Ballard, and B. L. Bailey, presented at 63rd General Meeting, Electrochemical Soc., May 13, 1937, preprint no. 63-27.

8 "The Metal Cobalt and Some of Its Uses," by B. E. Field, *Mining and Metallurgy*, vol. 14, July, 1933, p. 303.

9 "Hard Facing," by E. E. LeVan, *American Welding Society Journal*, vol. 13, November, 1934, p. 10.

10 "Nitriding," by V. O. Homerberg, *Iron Age*, vol. 138, October 15, 1936, p. 49.

11 "A Study of Nitriding," by V. O. Homerberg and J. P. Walstead, Transactions of the American Society for Steel Treating.

12 "Differential Hardening by Induction," by M. A. Tran and W. E. Benninghoff, presented at meeting of the American Society for Metals, Oct. 19, 1936; abstracted in *Iron Age*, vol. 138, Oct. 29, 1936, p. 26.

13 "Structure of Hard-Surfacing Weld Deposits," by A. G. DeGolyer, *The Welding Engineer*, October, 1937, p. 36.

14 "Process of Depositing Chromium," by C. G. Fink, U. S. Patent No. 1,581,188.

15 "Chromium Plating in the Paper Industry," by D. H. Bissel, *The Paper Industry*, vol. 12, November, 1930, p. 1397.

16 "Wear of Metallic Surfaces," by E. E. LeVan, *Metal and Alloys*, vol. 8, July, 1937, p. 207.

17 "Case Hardening With Ammonia Gas," by V. O. Homerberg and J. P. Walstead, Trans. A.S.M.E., vol. 53, 1931, paper MSP-53-1, p. 1.

18 "The Relative Wear of Some Hard Metals," by R. B. Freeman, *Metal Progress*, vol. 31, 1937, p. 280.

19 "What Process for Wear Resistance?" by M. C. Smith, *American Machinist*, vol. 81, May 5, 1937, p. 365.

20 "Wear Testing," *Metal Progress*, vol. 31, January, 1937, p. 41.

21 "Surface Stress and Wear," by N. Swain, MECHANICAL ENGINEERING, vol. 59, July, 1937, p. 528. Condensed from *Machinery* (London).

22 "Wear Tests," by C. O. Reid, *Testing*, vol. 1, Feb., 1924, p. 93.

23 "Brinell's Researches on Resistance of Steel and Iron to Wear," by H. A. Holz, *Testing*, vol. 1, February, 1924, p. 104.

24 "Hard Facing Materials Data," Haynes Stellite Company, Kokomo, Ind.

25 "Oil Field Welding," Stoody Company, Whittier, Calif., 1934.

26 "Gold in Your Own Back Yard," Stoody Company, 1935.

27 "Cemented Carbide for Reducing Wear on Tools and Machine Parts," Booklet No. WR-35, Carboloy Company, Detroit, Mich.

28 "Properties of Haynes Stellite," Haynes Stellite Co., 1936.

29 "Haynes Stellite Products in the Oil Fields," 1930.

30 "Welding Electrodes," General Electric Co., Schenectady, 1936.

31 "How to Make It Wear Longer by Hard Facing," The Lincoln Electric Company, Cleveland, Ohio, 1936.

32 "Welding Electrodes," Wilson Welder & Metals Company, New York, N. Y., 1935.

33 "Chapmanizing," The Chapman Valve Mfg. Company, Indian Orchard, Mass., 1937.

34 "Notes on Continuous Gas Carburizing," by R. J. Cowan, Trans. of the American Society for Metals, vol. 25, September, 1937, p. 843.

CONTROL *of* DUST EXPLOSIONS *in* INDUSTRIAL PLANTS

By HYLTON R. BROWN

BUREAU OF CHEMISTRY AND SOILS, U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

WITH VERY few exceptions, any dust, which will burn or oxidize readily and is fine and dry enough to form a cloud in air, will explode if the concentration is within certain limits and there is present a source of ignition sufficiently hot to ignite it.

Starch, grain dust, wood dust, powdered sugar, cork dust, soap powder, rosin dust, coal dust, sulphur, and aluminum powder are representative types of the dusts which have been found to be explosive. For the more explosive dusts a concentration of 0.02 to 0.04 oz per cu ft of air forms an explosive mixture which ignites at a temperature of 540 C. Tests to determine the pressure produced by dust explosions have been made with many different dusts in the laboratories of the Chemical Engineering Research Division of the Bureau of Chemistry and Soils in the U. S. Department of Agriculture. The maximum pressure, average rate of pressure rise, and the maximum rate of pressure rise for 133 of these dusts at different concentrations have been reported.[1]

In large-scale tests pressures of over 100 pounds per sq in. were recorded. Reports have been received indicating that pressures of over 200 pounds per sq in. were measured during tests made in Europe. Observations made at industrial plants in this country, following dust explosions, have indicated that it is impractical to build walls strong enough to withstand the pressures produced. In one case a 16-in. reinforced concrete wall was blown out by the explosion; in a grain-elevator explosion a section of the concrete storage tanks together with their contents, estimated to weigh more than 100,000 tons, was lifted at least a foot and moved sidewise on its foundation about 8 inches.

The dust-explosion hazard exists in thousands of the country's industrial plants in which explosions each year cause heavy life and property losses. More than 300 persons have been killed and more than $35,000,000 worth of property has been destroyed in dust explosions in this country during the last 20 years. The plants in which these explosions occur are not always old and poorly operated. In fact, most of the recent losses have occurred in what would be considered modern, well-equipped, and efficiently operated industrial establishments. The hazard must be recognized and protective measures adopted to reduce or prevent such losses.

PREVENTION FIRST

Of course, explosion prevention should be the first thought. Industry has learned to build fire-resisting buildings and to pay more attention to fire prevention, but it still provides fire extinguishers and fire-protection equipment in plants. The same procedure should be followed in combating the dust-explosion hazard. Knowing the requisites of a dust explosion—a dust cloud and a source of ignition—all possible precautions should be taken to prevent the formation of dust clouds and to eliminate possible sources of ignition.

Cleanliness has always been and continues to be the best and easiest precaution in providing dust-explosion protection. Considerable progress has been made in developing effective dust-collecting equipment and the use of such equipment, wherever practical, provides protection for many processes in various types of plants.

To some extent, it is also possible to eliminate sources of ignition. Explosion-proof electrical equipment is now available and can be used to eliminate the electric spark or arc as a possible ignition source. Nonsparking tools and machine parts are obtainable and their use will greatly reduce the possibility of dust ignition by metallic sparks. It may be interesting to note that at the U. S. Department of Agriculture Dust Explosion Testing Station at Arlington, Va., both sulphur-dust clouds and aluminum-dust clouds have been ignited by sparks from a piece of steel held against an emery wheel. Static electricity can be eliminated as a possible source of ignition by proper grounding of belts and moving parts of machinery.

INERT GAS

According to the above suggestions, sufficient protection can be provided where the dust is a by-product and easy to collect and remove, and the sources of ignition are recognized. In plants where the dust or powdered material is the product being manufactured other precautions are necessary. In such cases it becomes particularly important to guard against ignition of the product during processing. The use of inert gas, such as carbon dioxide or nitrogen, has been found very effective for both fire and explosion prevention where it can be used to reduce the oxygen content of the atmosphere within the grinding, sifting, or conveying equipment in which the material is being processed. The oxygen reduction necessary varies for different dusts, but tests have shown that for nearly all of the cereal dusts now generally recognized as explosive, it is impossible to produce an explosion or propagate flame when the oxygen content of the air in which the dust is suspended has been reduced from the normal 21 per cent to 12 per cent. A reduction to 8.5 per cent is necessary to prevent explosions of sulphur dust and it may be necessary to go still lower with other materials.

PROTECTION NECESSARY

In addition to all the safeguards previously mentioned, it has been considered desirable in many cases to give consideration to the construction and location of buildings. This is particularly true in industrial plants where dust clouds or sources of ignition may occur through mechanical failures or conditions beyond the control of the operator.

With the knowledge now available concerning dust-explosion

[1] "Explosibility of Agricultural and Other Dusts as Indicated by Maximum Pressure and Rate of Pressure Rise," by Paul W. Edwards and L. R. Leinbach, Technical Bulletin No. 490, U. S. Department of Agriculture.

Contributed by the Safety Committee for presentation at the Annual Meeting, New York, N. Y., December 5–9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

pressure, the futility of attempting to build strong enough to withstand the pressure should be recognized and attention directed toward construction features which will help prevent explosions or provide vents if one should occur.

It is seldom practical to separate the type of plant in which the dust-explosion hazard exists into widely scattered or segregated units like a powder or explosive-manufacturing establishment. It is possible, however, in many cases to divide a building into sections with unpierced fire walls and thus prevent an explosion in one section from spreading to another. The desirability of releasing explosion pressure in the early stages was recognized some time ago and a room, gallery, and tower were erected at the Arlington Testing Station expressly for the purpose of determining the relationship between venting area, explosion pressure, and the extent of flame propagation.

The room, 4 × 5 × 5 ft, has a volume of 100 cu ft; the gallery, 2.5 × 2.5 × 20 ft, has a volume of 125 cu ft; the tower, 3 × 3 × 18 ft, has a volume of 162 cu ft; the total volume of the structure is 387 cu ft.

Vents in the room consist of hinged metal doors and window sashes. The metal doors range in size from 0.1 sq ft to 1.55 sq ft and the sashes contain approximately 3 sq ft of glass. The gallery has eight roof vents, each 1 sq ft in area, covered by hinged doors. There are also eight fixed-glass windows with an area of 1.3 sq ft each. The opening into the tower, which is the full size of the gallery, may be closed when the gallery is used as a unit. The tower contains one swinging panel about 7 sq ft in area, five hinged doors, each 1.55 sq ft in area, adjustable vents on top ranging from 0.1 sq ft to full cross-sectional area of 9 sq ft and six fixed-glass windows with an area of 1.7 sq ft each.

A series of tests was made at the station to determine (1) the ratio of venting area to room or building volume to provide safe venting of explosions, (2) suitable types of venting equipment, and (3) the most effective location of vents.

REQUIRED VENTING AREAS

The first step in determining the area required for the venting of dust explosions was to select a pressure at which it was believed structural damage would not occur. This, of course, depends upon the type of building to be vented, but for the heavy reinforced-concrete type of structure generally used to house the dust-producing industries it is believed that sufficient venting area should be provided to prevent explosion pressure not to exceed 300 lb per sq ft.

The results obtained in a series of 66 explosions indicated that it is necessary to provide 1 sq ft of venting area for each 80 cu ft of volume in order to release at less than 300 lb per sq ft pressure an explosion of grain dust in a cube-shaped or approximately square room. In a series of 58 explosions it was found that approximately 3 sq ft of venting area should be provided for each 100 cu ft of volume to vent safely an explosion of starch dust in a cube-shaped room or in one which was approximately square.

No extensive series of tests was made with other dusts, but enough information was obtained to indicate the pressures produced in comparison with starch and grain dust. The results obtained with sugar, wood flour, sulphur, cork, powdered-milk, soap powder, wood charcoal, and similar products indicated that the venting area required for these dusts ranges between the limits for grain dust and starch.

FIXED-GLASS VENTS

In some cases a lightly placed roof and large free-swinging doors may be considered as vents, but, as a rule, windows represent the venting area which can be conveniently used for explosion pressure release. Accordingly tests were made to determine the breaking strength of glass in the sizes and types generally used in industrial plants and generally accepted as explosion vents.

Table 1 gives the results of these tests.

TABLE 1 DUST-EXPLOSION PRESSURE NECESSARY TO BREAK GLASS

(Pressure in lb per sq ft)

Type of glass	Size of pane: 10 × 14 in.	12 × 18 in.	14 × 20 in.	16 × 24 in.
Picture glass		513	368	
Single-strength *A* quality		470	392	
Double-strength *A* quality	900	637	510	419
1/8 In. ribbed		270	169	
3/16 In. ribbed		655	387	
1/4 In. ribbed		Unbroken at 1000	501	
1/4 In. wired	Shattered at widely varying pressures			

It was a surprise to all of the engineers engaged in this work to find that double-strength *A* quality window glass of the size ordinarily used in factory windows was capable of withstanding such high dust-explosion pressure. Undoubtedly, too much dependence has been placed on fixed glass as a means of venting dust explosions in industrial plants because the results given in the table clearly show that such glass cannot be depended upon to release pressures below the point at which structural damage will occur, except perhaps where the 1/8-in. ribbed glass is used. The 637-lb per sq ft reading for the 12 × 18-in. double-strength glass, a size generally used in factories, means that under such conditions a wall, ceiling, or floor, 10 × 10 ft in area would be subjected to a pressure of more than 30 tons. It is quite likely that in such cases the entire window frame would be blown out of its setting at a pressure lower than that shown as the breaking pressure of the glass; but that is another phase of the venting problem.

There was some indication in the tests that venting of dust explosions through fixed glass might be accomplished at a safe pressure by using larger panes of glass. It will be noted that the 16 × 24-in. glass broke at about two thirds the pressure the 12 × 18-in. pane was able to withstand. This plan was not recommended because it was realized that unusually large panes would be necessary and the changing of existing installations and standardized construction practices would be impractical.

SCORED-GLASS VENTS

The comparatively low pressure at which the 1/8-in. ribbed glass broke in the tests just described led to another series of tests to determine the effect of scoring fixed glass in window frames to reduce its breaking pressure and thus increase its effectiveness as an explosion vent. It was noted that this particular type of glass broke at a much lower pressure when the panes were installed in the explosion chamber with the ribs on the outside than when they were placed with the ribs on the inside.

Similar results were noticed when plain glass panes were scratched with a glass cutter. The best results were obtained with a diagonal or cross scoring with the scratches starting about 2 in. from the corners and with a gap of 2 in. in the center. The 2-in. space at the corners and the 2-in. gap in the center prevent cracks from starting along the scratches when such scoring is used on glass in factories where heavy vibration occurs. The tests also showed that scoring with a diamond cutter was more effective than scoring with a steel

TABLE 2 COMPARISON OF DUST-EXPLOSION PRESSURES NECESSARY TO BREAK UNSCORED AND SCORED GLASS

(Pressure in lb per sq ft)

	Size of pane	
Double-strength *A* quality	12 × 18 in.	14 × 20 in.
Unscored	637	510
Scored with steel wheel	119	120
Scored with diamond cutter	78	85

wheel. Table 2 shows the comparison in the breaking pressures of scored and unscored glass.

The figures in Table 2 are based on a limited number of tests and, consequently, one or two of the results are not in line with the expected trend. However, the series of tests is being continued and later results may be somewhat different. The table shows, however, that it is possible by scoring fixed glass to reduce its breaking strength to the point where it can be used to vent dust explosions and prevent the building up of destructively high pressure. It is interesting to note that scoring the outside of fixed glass, as recommended, greatly weakens the glass against pressure from within without materially lowering its resistance to wind pressure from without.

MOVABLE VENTS

Following the series of tests to determine the breaking pressure of plain and scored glass, an opportunity was presented to compare the merits of the various types of swinging or movable vents. All of these venting devices have particular advantages, depending upon the type of structure in which they are used, the cost, and the frequency and severity of the explosions in which they may operate. The outstanding result of the tests was the great advantage which all of the vents tested had over fixed glass in providing quick release at low pressures. Many of these devices which consist of hinged free-swinging or counterbalanced panels or window sashes can be set to operate at pressures of less than 5 lb per sq ft.

It is not feasible in many cases where fixed glass is now installed to replace the present sash with venting frames. In such cases it is recommended that the glass be scored as previously described or the entire frame be arranged to swing outward by hinging at the top.

EQUIPMENT VENTS

There are a number of industries in which the explosive dust is confined within the processing equipment. Spray drying chambers, grinding and sifting apparatus, and dust collectors are examples of such cases. It is desirable to vent such equipment directly to the outside of the building and, where the enclosure or shell of the machine is of light construction, a vent area of not less than 1 sq ft for every 30 cu ft of volume is recommended. For more substantial equipment having reasonably high bursting strength, a smaller vent can be used. Attention should be given to the design and construction of both equipment and vents to be sure they are capable of withstanding explosion pressure. In many cases special caps and seals are necessary in equipment vents, but their use should not permit the escape of an explosion from a machine into a room where workmen are employed.

LOCATION OF VENTS

In all of the tests herein referred to considerable data were obtained concerning the location and distribution of venting areas. It was found that there is a great advantage in being able to vent an explosion at its source or before the pressure has a chance to build up. Tests at the Arlington Testing Station proved that a cube-shaped room with vents or windows on all sides is the type which can be most effectively vented. When explosions were produced in the gallery which was 20 ft long and only 2.5 ft wide and high, the pressure built up rapidly as the explosion propagated from one end to the other. An explosion in this gallery could be vented without glass breakage through a one-half sq ft vent located at the end where the dust cloud was ignited, but if this vent was closed the pressure built up so rapidly that a 2-sq ft vent located 20 feet from the source of ignition was not sufficient to vent the explosion without breaking glass. In other words, in a long narrow room it may be impossible to provide sufficient venting area at one end alone to release an explosion before destructively high pressures are reached.

It is for this reason that suggestions have been included in certain safety codes covering the dimensions of rooms in which a dust-explosion hazard exists.

SAFETY CODES

The Dust Explosion Hazards Committee of the National Fire Protection Association, formed with the cooperation of the U. S. Department of Agriculture, has prepared safety codes for the prevention of dust explosions covering the hazard in a number of industries. The following codes have been completed and approved:[2]

1. Safety code for the prevention of dust explosions in starch factories (Z12.2–1935)
2. Safety code for the prevention of dust explosions in flour and feed mills (Z12.3–1935)
3. Safety code for the prevention of dust explosions in terminal grain elevators (Z12.4–1935)
4. Safety code for pulverizing systems for sugar and cocoa (Z12b–1931)
5. Safety code for the prevention of dust ignitions in spice-grinding plants (Z12h–1931)
6. Safety code for the prevention of dust explosions in wood-flour manufacturing establishments (Z12g–1930)
7. Safety code for the installation of pulverized-fuel systems (Z12.1–1935)
8. Safety code for the prevention of dust explosions in coal pneumatic cleaning plants (Z12f–1930)
9. Safety code for the use of inert gas for fire and explosion prevention (Z12i–1931)
10. Safety code for the prevention of dust explosions in woodworking plants (Z12.5–1935)

Additional detailed codes are in the course of preparation by the committee. Codes covering the dust or dust-and-gas explosion hazard in coal mines have been formulated by the U. S. Bureau of Mines in cooperation with other agencies.

Many of the studies originally planned to develop methods of controlling dust explosions have not yet been completed and additional experimental work will be necessary. The venting area required to release the pressure in explosions of dusts other than those tested should be determined. A study of flame travel during dust explosions in different-shaped rooms and a series of tests to determine explosion pressure produced in deep bins or vaults is also desirable. The heavy losses of life and property already caused by dust explosions in different lines of industry are an incentive to carry on work which will aid in reducing or eliminating this hazard.

---

[2] American Standard Safety Codes, American Standards Association, New York, N. Y.

Also included in "Safety Codes for the Prevention of Dust Explosions," Bulletin No. 562 and Supplemental Bulletin No. 617, Bureau of Labor Statistics, U. S. Department of Labor.

Development of the SHEARING *of* TEXTILE FABRICS

By RALPH L. MARBLE

CURTIS AND MARBLE MACHINE COMPANY, WORCESTER MASS.

SHEARING or cropping of textile fabrics, which has an important place in the finishing of various goods, has grown from a crude hand method to a highly efficient machine process.

Originally, cropping or shearing was done to try to even the nap on the surface of woolen goods. Today many types of goods are sheared at speeds ranging from 4 to 100 yards a minute. The surface is evened, or fancy effects created, with a minimum amount of effort by the operator.

It was not until about 1700 A.D. that we find any trace of efforts being made to remove or to even the nap on fabrics. The crude tools were hand-worked, and were similar to sheep shears in that they were operated by a spring handle, but they had longer and broader blades with blunt or square points.

The more common type of these hand shears had two heavy steel blades about 18 to 24 in. long connected at one end by a band of steel in circular form, which acted as a spring.

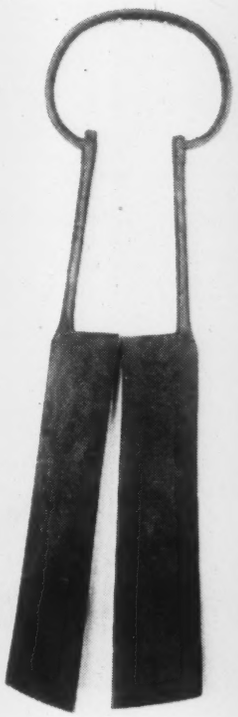
In using these hand shears, the cloth was held smooth and flat on a table and the entire surface gone over by successive cuts until the nap was cut as evenly as possible. Each cut meant that the cropper had to bring the blades past each other by hand, and when it is realized that most fabrics today get from 60 to 100 cuts per inch, it is easily understood what a tedious and crude process this was in the beginning.

As was the case with the introduction of machinery for spinning and weaving, the first efforts to mechanize cropping met with a great deal of opposition, so that the change from hand labor was rather slow. The hand croppers were among the earlier opponents of the introduction of mechanical methods into the textile industry. Proud of the callouses or "horns" on their hands, they destroyed many of the earlier "frames" and the military authorities were called in to support the more progressive mill owners. The riots caused by the introduction of the mechanical cropping machines is very well described in Phyllis Bentley's novel, "Inheritance," which is a story of the early development of the worsted industry in Yorkshire.

The first move toward mechanization was to use a foot treadle with a cord attached to one of the blades to draw the two blades together instead of squeezing them by hand. This naturally led to the use of the mechanical movements of the crank, eccentric, or beam, and we find several arrangements that used the hand shears as a basis. The most satisfactory one was rather simple and was used in this country to some extent. A shaving or shearing cut was obtained by using a stationary blade in contact with a movable blade held in an oscillating frame, the point of cutting being directly over a rest over which the cloth passed. The oscillating motion was very fast and the clearness of the cut and ease of adjustment made this arrangement superior to previous devices.

Up to about 1790 all the changes were minor, and the oscillating motion was retained in some form. In some cases the cutting blade was mounted spirally on a roll and worked against a stationary blade.

The next step was to go from the oscillating motion to the revolving of the roll holding the movable blades, and there was a patent issued by the United States Patent Office in 1792 for a "wheel of knives" or cloth-shearing machine. This machine had a revolving structure with 12 arms, to the extremities of which were fastened the steel blades. A quadrangular frame which held four stationary blades was built around the revolving cutter, and the blades were so adjusted as to come in contact. This device was evidently not used to any great extent, but it contained the embryo idea of a rotary cutter and stationary blade which is used today.



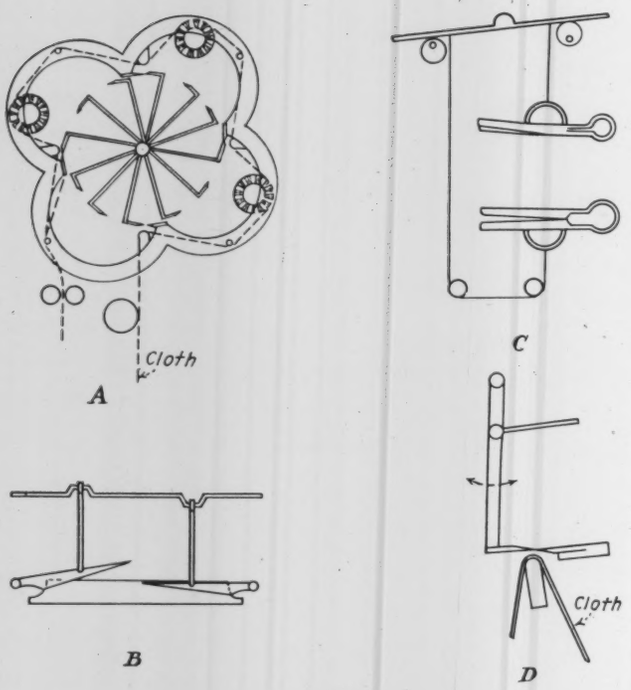
OLD HAND SHEARS

About 1812 a shearing machine was brought out which had a revolving cutter with two curved blades. In the same cylinder with the two blades were placed two rows of brushes, so that the shearing and brushing operations were combined. This machine had no stationary knife, the cutting being performed by the hooked edge of the revolving blade. Also, in 1812 or a little earlier, a William Hovey, of Worcester, Mass., advertised a special shearing machine for woolen fabrics. This machine used a rotating cylindrical cutter with steel strips soldered to a roll which was brought into contact with a stationary blade. Most of the early machines used this type of cutting blades.

The first power machines were crude wooden-framed affairs using only one set of blades.

They were slow-running, and the goods were passed through the machine and folded or rolled at the back. The goods were then brought to the front of the machine and this was done as many times as was necessary to complete the shearing. The so-called perpetual shear was later introduced, where the cuts of cloth were

Contributed by the Textile Division and presented at the Fall Meeting, Providence, R. I., Oct. 5 to 7, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



FOUR TYPES OF VERY EARLY SHEARS

(In *A* is shown the "wheel of knives" patented in 1792 by Samuel Dorr of Albany; *B* shows the use of one stationary blade and two swinging blades worked by a crank; in *C* are two sets of blades worked alternately by cams; *D* shows one of the best of the earlier types of shears using a stationary and a movable blade held in an oscillating frame.)

sewed into an endless band, and run through the machine with no handling until the work was finished.

From the time of this shear, which was used largely for woolens, the change in design and improvements in shearing machines followed closely the introduction of new fabrics and methods. The changes and improvements noted in this discussion will be those of American machinery and methods, as the advancement in this country has been much more rapid than it has in England and on the Continent.

THREE ELEMENTS OF THE SHEARING MACHINE

The cutting or shearing member of a shearing machine consists of three units; the rotating unit or "revolver," the stationary member or "blade," and the stationary support, or "rest," for the cloth while being sheared.

The American revolvers or rotating members of the cutting unit of today are made by grooving a bar spirally and inserting strips of hardened steel that are backed with iron. These "strips" are made in different twists, determined by the goods to be sheared, by the size of the revolver bar, and by the number of strips used. After the strips have been securely fastened in the bar by hand staking, the revolver is ground to a cylindrical shape by an emery wheel with the revolver turning on its own bearings. The soft iron on the back of the strip is then beveled off at the top and the revolver is put on a long grinding cylinder, using oil and fine abrasive to bring out a sharp cutting edge.

The stationary or ledger blade having a hardened-steel cutting edge is riveted to a suitable "back," ground true on the edge, and a "seat" for the revolver is ground in on the contact face. This blade varies in thickness and in width to meet the conditions of different fabrics and of the machine on which it is used.

When the revolver and blade are ready they are placed in a suitable frame and ground together by a process known as "back grinding." The revolver and blade are then set together, and by running the revolver backward and using oil and fine abrasive, the parts are ground together and a set of keen-cutting blades is obtained.

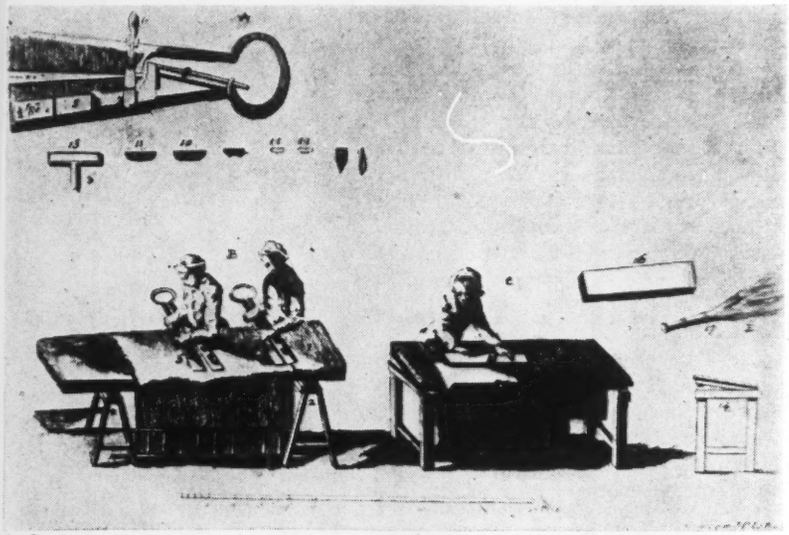
Extensive research has been made to obtain a steel having the properties required for a correct cutting temper and capable of retaining that cutting quality when subjected to the constant fiber-severing operation necessary for use day after day.

It is interesting to note the difference between American and foreign constructions of shear blades used at the present time. The two main points of difference in the foreign construction are (1) that the strips of the revolver are not fastened into a groove, but are held tight against the outside of the revolver bar by locking nuts at each end of the strips, and (2) that the ledger blades are in many cases held on to the supporting "back" by screws.

When making shears for different classes of material, the construction is distinguished by weighing the nature of the pile to be cut and the depth of cut best to take at any one time. The type of shear suitable for one sort of shearing could prove quite unsuitable for another class of goods. As an excellent comparison as to the significance of this statement, ordinary hand shears or scissors may be used for the illustration as to the principles involved in power shearing machines.

For cutting ordinary sheets of paper, scissors with long and light blades only are needed. For cutting thicker substances, say several layers of cloth, hand shears with heavy blades, like tailors' shears, are needed. For cutting hard material like sheet metal, hand shears with very heavy blades, like tinsmiths' shears, are required.

The same principles apply to the revolver and blade of a shearing machine. Cutting parts for the particular class of goods to be sheared are made with the revolver spirals and ledger blade of sufficient weight and rigidity to withstand

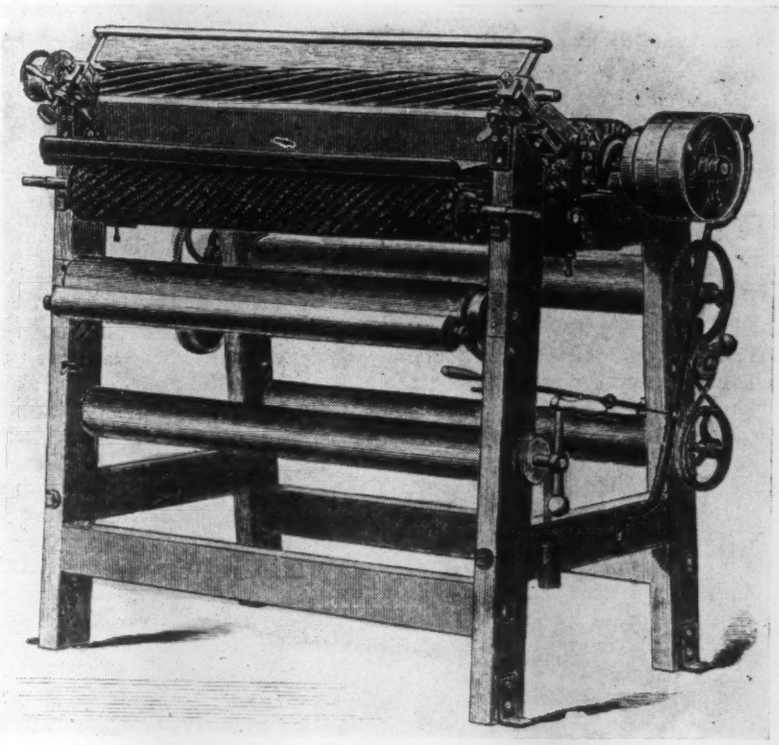


REPRODUCTION OF A WOOD ENGRAVING FROM AN OLD FRENCH BOOK SHOWING HAND CROPPERS AT WORK

the strain of cutting off anything presented to them. Other parts in the construction of the shear are likewise made with the idea in mind of the particular work to be accomplished.

Today, the textile industry requires a wide range of shearing machinery. Machines are made for all types of woven and knit goods as well as for cordage and twine, cocoa mats, wool skins, braids, upholstering materials, machine brushes, embroidery goods, curtain or clip spot goods, and also for creating fancy effects on certain types of fabrics.

To trace the changes and improvements in machines made since 1850 to 1875, different types will be mentioned, as, with the introduction of new fabrics and methods, new machines were developed.



A WOOLEN SHEAR MADE BEFORE 1865

As woolen goods were the first to be sheared, the woolen shear was the first to be improved. The basic principles are still used, but the present-day woolen and worsted shear accomplishes in one run at cloth speeds of 20 to 40 yards a minute what had to be done in several runs with the original shears.

Where the first machines had only one set of blades, the latest machines have from three to six sets, and as worsted goods are sheared on both sides, the modern shear is designed to meet this condition. Woolen and worsted shears are usually made as multicutter machines, with the first cutter operating on the back, and two or more cutters on the face, of the goods. This, of course, tends toward increased production and lower labor costs.

The brushing of the goods as they pass through the shear, together with the various adjustments of the blades, has been constantly improved, so that the standard of work turned out has kept pace with improved methods in the other divisions of the finishing routines.

For carpet shearing before the early 1870's, the woolen type of shear was used, as Brussells and ingrain carpets, which were in vogue then, were not very much different from a heavy woolen cloth. As the mills brought out new types of floor coverings, new types of machines followed. In the 1890's a shear for 9-ft rugs was designed, followed in early 1900 by the 12-ft machine. The cutting parts of these wider shears naturally grew heavier and larger, but the main design of the machines was changed but little. With the introduction of machines for 15- and 18-ft rugs, several changes were made to make the machines more efficient and easier to operate. As the cutting parts were very heavy (the revolver alone weighed as much as 2000 lb), to lift the blades to allow a seam to pass by required quite some strength, even though the parts were counterbalanced. To overcome this and to give added efficiency, an electrically controlled lift was applied, together with a variable-speed motor for the feed motion. The machines as now made are operated entirely by push buttons which control all the movements of the shear. The carpet can be run forward, backward, or jogged along, and the cutting parts can be raised or lowered for the seams with no manual effort on the part of the operator.

The design of shears for pile fabric, such as plushes, velvets, corduroys, velveteens, and duvetyns, takes into consideration the fact that the pile must not be crushed or matted during the process. Therefore most pile-fabric machines are of simple construction.

The most important parts of a velvet shear are its cutting parts so that these need to be made to give the best results on each type of fabric.

High-pile plushes naturally require heavier cutting than low-pile plushes and the blades are made accordingly. These machines have not changed radically from the early models, but, of course, have been improved mechanically in some ways that do not stand out quite as prominently as on some other types of shears.

Creating fancy effects is an interesting process. As far back as 1860, patterns were being cut on woolen fabrics. These patterns consisted of straight lines, diagonal stripes, and rather intricate designs. The general idea behind all design shearing is that it is cheaper to get the effect by shearing than by weaving.

The basis of most of the older style of figure cutting was a napped woolen fabric. Designs were cut in several ways according to the type of design to be made. There are three basic ways of cutting designs: By using a cloth rest made with high and low areas; by using a ledger blade that has been cut away in places; and by notching the strips in the revolver in such a way as to cut only certain portions.

The pattern revolver was very expensive as a new revolver had to be made for each pattern, and unless there was a tremendous production, the cost was out of proportion. This same objection applies to the cut-out ledger blade.

The pattern rest was the simplest and easiest to use as the rest could be made either flat or in roll form. With a flat rest with parts of the plate cut away, straight lines could be made, and when used in connection with a cam motion for lifting the blades, a square design could be cut on the goods.

Both the stationary rest and roller rests are used today for creating fancy effects on blankets, overcoatings, and pile fabrics.

One complicated shear was built so that it would be adjusta-

ble for all types of patterns, but the demand for such a machine was so limited it was never used to any extent. All pattern cutting is done on a regular shear that has had certain modifications made in it at a comparatively low cost.

In handling cotton goods such as sheetings, the original machine combined both cleaning and shearing in one unit. These machines generally had two to three cutters for each side of the goods, with about the same number of cleaning rolls, and ran about 30 yards a minute. The purpose of the process was to clean off any vegetable matter left on the goods, and to shear off as much nap as possible in the event the goods were to be printed.

Today, the problem is one of production. With the introduction of the automatic magazine loom, every time a bobbin is changed a thread is left hanging from the selvage. These must be trimmed off, and if this is done by hand, low production or a high labor cost results. The present-day automatic cotton shear was developed to meet this condition so that now the loom rolls are sewed together and the cloth is fed into a scray, through a brushing machine, and then through a four-cutter shear to a roll up. This is done at speeds of 80 to 120 yards a minute. The shear requires no attention from the operator, as the blades and cloth are protected from damage by an automatic device which detects seams or foreign substances in the cloth, and renders the shearing action operative or non-operative.

Mechanically, the shear is simpler today and has a number of interesting features. Each revolver has its own motor, insuring a constant speed and the absence of bearing trouble, due to the elimination of all belting. The motor used is a special shaftless type with the rotor mounted directly on the revolver shaft. The machine is equipped throughout with roller or ball bearings, and has an efficient suction system with hoods for each set of cutting parts to remove threads and lint cut off by the blades.

The automatic device which controls the cutting action works through a detector motion electrically connected through a timing device to the revolver motors. Each time the detector is actuated by a seam or foreign substance in the goods, the revolver motors reverse and run in noncutting direction until the seam, or whatever energized the detector, is beyond the last cutter, when motors return to cutting rotation. This operation, at a cloth speed of 100 yards per minute, takes about two seconds. With the loom rolls running from 100 to 250 yards in length, the motors are reversed about once a minute, which is far faster than any operator could act throughout an eight-hour working day.

For cotton goods like dotted marquisettes which are so largely used for curtains and in late years for shirting and dress goods, shears are arranged to remove all the loose or floating threads on the surface which connect two of the woven-in spots. In a great many cases the body of the goods is very light and delicate, and the shearing must be done closely and evenly without disturbing the basic weave.

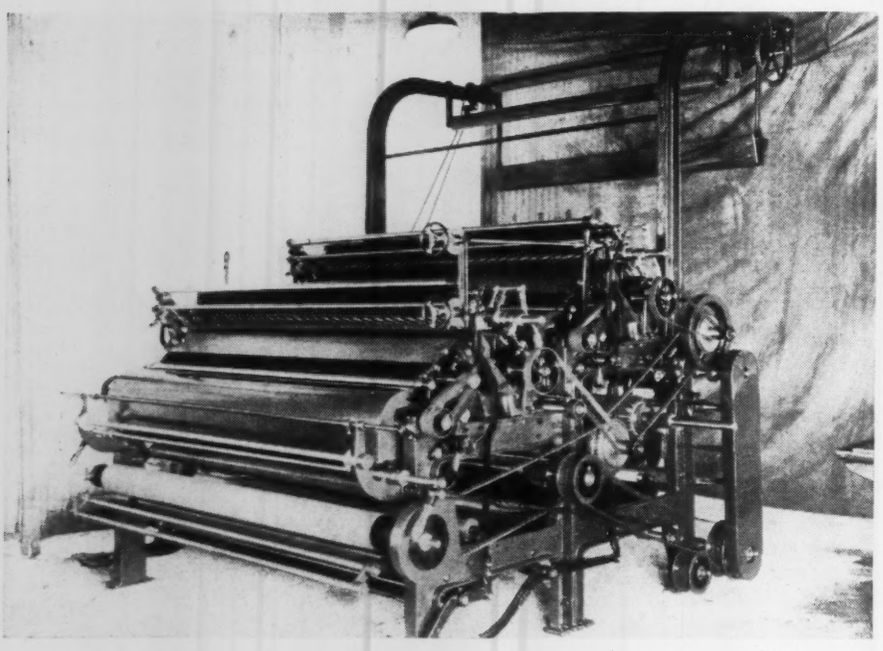
Here again the trend is toward more production so that the machines are being run faster and require certain changes in design to keep up with the present-day standards. Patterns are more intricate, so that both men and machines have had to change to keep production up and costs down.

Among other types of shears are those for use on cocoa mats where a coarse, heavy fiber must be trimmed off evenly. These machines require heavy cutting parts, and are made to handle the thick, heavy mats as easily as possible. The wool or fur of individual sheepskins or fur skins are cut to an even surface for use in coats, capes, and gloves.

Small shears are made for handling narrow braids and upholstery materials which are often made with a pile surface. Pompon shears do the work of cutting the ball handles that are seen in automobiles. These are cut to ball shape by a swivel attachment used in connection with a small set of cutting parts.

Different types of machine brushes are sheared, either with straight, convex, or concave blades, according to the shape to which the bristles must be cut.

Many kinds of twine, rope, and cordage are sheared to remove the "whiskers" or projecting fibers. This is done either in connection with the twisting or spinning process or as a separate operation after the twine is finished.



A MODERN DOUBLE-CUTTER WOOLEN SHEAR

Embroidery goods have to be sheared on both sides to remove surplus threads running between the designs. Vertical cutting parts are used to trim loop threads from the edges of Turkish towels, as no shear could run on the surface of terry cloth without cutting the loops of the towels.

Shears are used on Oriental carpets to remove a slight amount of pile to bring back the color and improve the appearance. These shears are made very much the same as a lawn mower and are used in much the same manner.

A sound knowledge of fabrics as well as good machine design is necessary to produce an efficient shearing machine that can be judged by present-day standards. Using the same principles contained in the first mechanical shearing or cropping machine, American manufacturers have aimed toward simplification of design, ease of operation, quicker and finer adjustments, together with automatic devices, so that the quality and quantity of work produced will result in a lower labor cost and a better fabric to offer to the public.

FOUNDRY METALS

Abstracts of Three Papers Dealing With Cast Steel, Malleable Cast Iron, and High-Strength Gray Iron

[Recent advances in foundry practice and metallurgy and in the substitution of welded for cast machine parts have made it necessary for engineers and designers to familiarize themselves with these developments. With this object in view the Machine Shop Practice Division of The American Society of Mechanical Engineers sponsored a session at its meeting which was held in Rochester, N. Y., May 10 to 12, 1938, at which the three papers abstracted in this issue were read and discussed.—EDITOR.]

Cast Steel or Welding?

BY F. A. LORENZ, JR.[1]

IN PRESENTING this paper it is assumed that the engineers and designers who read it are familiar with the outstanding characteristics of cast steel; its exceptional strength and toughness, its malleability and high ductility, its remarkable rigidity, excellent damping, and machining qualities, the facility with which it can be welded, and its high resistivity with respect to various kinds of corrosion, elevated temperatures, critical stresses, and heavy impacts. A similar knowledge of the advantages of welded fabrication is presupposed.

Probably 98 per cent of the steel castings now being produced by the steel-casting industry require little or no study to determine whether they can be improved upon by fabricating them from available wrought-steel shapes by means of welding or by a combination of cast and welded construction. There probably also exists an equally high percentage of designs that are now being fabricated by welding with which castings could not compete.

There remains, however, in each field a narrow zone embracing jobs that are susceptible to further study to determine whether to put a casting into a welding shop or a welded structure into a steel foundry. Moreover, the same problem arises in connection with many new designs not previously made by either method. In such cases the question of whether to weld or to cast is often a really perplexing problem upon which this paper will attempt to throw some light.

STEEL FOUNDRYMEN NO LONGER ATTEMPT THE IMPOSSIBLE

Not many years ago the first contact the foundryman had with his order for castings was upon arrival of patterns and core boxes at the foundry door. His training had been to find ways and means to produce castings from patterns as received. His skill, brains, and experience were utilized to get results only. He assumed that the engineer and patternmaker were conversant with what was wanted, and with the steel foundry's production problems. He soon learned, however, that changes in design to facilitate molding or to reduce production costs naturally were not uppermost in the minds of men primarily interested in another phase of industry.

The modern steel foundryman questions irrational designs and cooperates with the designers and engineers to the end that sound castings will result. If cast steel is not the answer most steel foundrymen will frankly say so, thus avoiding subsequent trouble for both the foundry and the user.

EARLY MISTAKES IN DESIGNING WELDED STRUCTURES

Paralleling the early history of steel-casting design, lack of precedent hindered the designer in his initial attempts to produce welded structures. Usually such structures were not much more than copies of their cast or riveted predecessors. The cast-iron or cast-steel structure was merely replaced, part for part, with rolled steel and shapes. This resulted in nothing gainful except perhaps a slight saving in weight, often offset by increased labor costs.

Far-sighted welding engineers soon discovered it would be necessary to devote more thought to improved design. They recognized the fact that a new medium was at hand with which they might express their ideas. Here was an opportunity to break away from tradition. As might be expected, the welding engineer swung too far in the direction of excluding steel castings. Many designers entirely ignored the steel foundry's existence. Today, it is generally recognized that the steel casting has a very definite place in the present and future development of welded fabrication.

In a complex structure, a steel casting can often be substituted for intricate welded shapes. The cost of a finished construction produced entirely by welding increases directly with the number of separate pieces involved and the number of inches of welding required.

STEEL CASTING AND WELDING ARE COMPLEMENTARY

We often hear and see the words, "casting vs. welding." This statement is misleading, for these elements are certainly not natural antagonists. A very definite relationship exists between welding and steel founding. Broadly speaking, these branches of industry are complementary rather than opposed to each other. An up-to-date steel foundry does welding. Likewise, an up-to-date welding shop uses steel castings where castings by virtue of their physical and economical characteristics are the proper medium. The possible combinations of steel castings, rolled-steel, and shapes are numerous.

A recent investigation disclosed a number of factors which

[1] Deceased. At the time the paper was presented, Mr. Lorenz was connected with American Steel Foundries Co., Chicago, Ill.

the designing engineer should consider in determining whether to weld or cast steel. Without attempting to analyze any particular structure, which after all should be the basis of a comparison to determine whether to weld or cast steel, it is simply pointed out that because the variety of types of welding is so great, the factors here considered apply to the parts of the structures that are critically stressed.

SHALL IT BE CAST OR WELDED?

The engineer is confronted with the question of economy rather than one of preference, as often times the sales price is the controlling factor, rather than the ability of the engineer to produce a welded construction, a cast unit or composite structure, or a combination of castings. In his comment, the author is largely guided by results of a two-year investigation by consulting engineers in his own plant where they were confronted daily with problems of cast design, welded design, and combination cast and welded design.

These studies showed that special, experimental, developmental, and new industrial-machine parts of medium weight are applications favorable to welding from a quick-delivery as well as an economical point of view. Shape limitations must be considered too; but since the comparable economies of either cast or welded construction are only determinable after simultaneous redesign, the user profits by reconsidering design with economy. In other words, structures that were originally fabricated by welding because they were of an experimental nature may later be more economically produced as steel castings for quantity production.

Conclusions regarding the question of whether to weld or cast steel are bound to be influenced by prejudices, but a closer analysis of cost and design emphasizes new and peculiar advantages and limitations both of welded and of cast construction.

AN INCONSISTENCY: "NO WELDS ON CASTINGS PERMITTED"

One of the most illogical rules with which the foundry is confronted is the specification, "no welding." Almost in the next breath the same engineer who has made such a specification will ask for a completely welded structure. With the advancement in the art of welding it would appear that at least there should be consistency in the designing engineer's mind as to what constitutes satisfactory or unsatisfactory welding, without increasing the production cost by a blanket "no welding" clause in casting specifications.

If it is satisfactory to weld plates and castings together, is there any logical reason for a provision prohibiting the steel foundryman from making a weld when it is recognized that the art of welding has advanced sufficiently to enable other branches of industry to do an acceptable job? Experienced steel foundrymen know and use discretion in repairing defects in steel castings. It is to be granted that such welding should be regulated by the nature of the defects and the use to which the casting is to be put, and should be performed with the proper preparation of the defects to be welded along with the proper preparation of welding rods and equipment.

Welding of steel is in reality a steel-casting process. The metal is melted and allowed to solidify without any working, except in occasional cases where some peening is done to the welded material. A weld to cast steel, therefore, simply adds another casting; whereas a weld to rolled steel adds a casting to a rolled product. It is not to be inferred that welds can be made more advantageously to a casting, but the author sees no logic for certain claims that it is more difficult to weld a casting than a rolled product. The same precautions must be taken in either case, and it is well recognized that the necessary precautions are increased as the air-hardening properties of the steel become greater.

An article, "Welding of Mechanical Equipment," in *Iron Age*, Oct. 14, 1937, says: "While these new alloy materials are safe for welding in competent hands, those of the higher strength range possess considerable air-hardening properties, necessitating due precaution in welding and gas cutting. Where practical they should be heat-treated to remove brittleness after welding."

Another precaution in addition to heat-treating after welding is to preheat in order to avoid cracks which are likely to occur by reason of the rapid cooling of the parent metal adjacent to the weld. Welds of alloy-steel castings, when properly made, have been known to have physical properties excelling those of the parent metal.

INITIAL COST NOT ALWAYS CONTROLLING FACTOR

It has been freely predicted that the great strides in the art of welding would offer a serious encroachment on the production of steel castings. It is well recognized that certain designs are now being made by welding or by a combination of welding and steel castings, which formerly were produced as steel castings. Both arts have their place. Whether or not a design should be ordered as a welded product or a steel casting will be determined primarily by the cost of the particular product for its life. The product, whether welded or cast, must stand up in service, and therefore, the initial cost must, in most cases, be the deciding factor. Steel castings do have a competitor; and with this live competition from welded products, it is believed that the steel-casting industry will be benefited rather than harmed.

STEEL CASTINGS SOLD ON BASIS OF DIFFERENTIAL COSTS

Although selling prices are of secondary importance in connection with designing and engineering problems, it does not seem amiss to take this opportunity to correct a misunderstanding which has arisen regarding the market values of cast-steel products.

There has probably never been a time in the experience of the steel-casting industry when as much intelligent work has been done on costing and classification of steel castings as at present. The industry has been at work, through the Steel Founders' Society of America and various subcommittees, studying costing methods and classification of castings as a means of quoting customers intelligently on their varied requirements of designs, weights, and quantities of castings.

It seems fitting here to state that steel castings are sold under hundreds of different price schedules covering different classifications and kinds of castings dependent largely upon the element of labor required for production. At present levels the average labor cost in steel castings may be conservatively stated as approximately 55 per cent of the total cost. The implication made by some that steel castings are quoted on the basis of so much per pound, regardless of the labor involved, is entirely foreign to the facts. It is to be regretted that such misleading statements are made proponents of welding.

Steel castings are not cheap. They are a quality product. Their market price is reasonable when it is realized that into their manufacture go high-priced metallurgical skill, costly raw materials, the use of expensive machinery and equipment, the cost of rigid expert inspection, and the hundred and one items of expense involved in turning out a carefully engineered product.

CONCLUSION

Steel castings have and will continue to have many desirable engineering characteristics for the designer. For many years to

come they will continue to give a reliable account of their dependability either as integral structures or when used in combination with other materials, made possible through the advancement of the arts of steel founding and welding and improvements in design.

High-Strength Gray Iron

BY A. C. DENISON

FULTON FOUNDRY & MACHINE CO., INC., CLEVELAND, OHIO

THE paper discusses the advantages that modern high-strength gray irons have to offer to the engineer. The discussion will be centered upon high-strength irons because it is in this field that gray iron offers the most to engineers. This fact is quite evident when one looks back to the early failures of ordinary gray iron in modern machinery designed for heavy-duty operation. At one time the gray-iron industry had nothing basically reliable to offer that was better than conventional gray iron. Engineers consequently lost faith in gray iron for important parts and were forced to turn to cast steel and other materials. Thus a practice has developed of using these other materials in parts where gray iron would work better if the gray iron had the required strength and dependable engineering properties. Modern foundrymen are sure that in high-strength gray irons they have dependable engineering materials which will not only cheapen but improve the design in many cases. For example, high-strength iron as compared to low-carbon steel (which had replaced ordinary gray iron) has far better metallurgical properties for heavy-duty gears driving a rubber calender mill. The strength is adequate, the hardness is higher, the compression strength to withstand tooth deformation is greater, and the pearlite matrix interspersed with fine graphite forms a combination of constituents that takes a glaze and gives superior wear resistance.

FIG. 1 A 6500 LB HIGH-STRENGTH GRAY-IRON MILL GEAR

FIG. 3 HEAT-TREATED HIGH-STRENGTH GRAY-IRON SHEAVES WITH HARDNESS OF 480 BRINELL

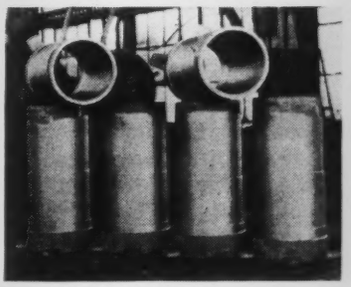


FIG. 2 HIGH-STRENGTH GRAY-IRON DIESEL-ENGINE CYLINDER LINERS

(Heat-treated and drawn to 280–300 Brinell hardness. Size can be held without grinding.)

SOME PROPERTIES OF GRAY IRON

Some of the valuable properties of gray iron that are of inherent engineering importance are discussed in the following text:

All gray irons possess good damping properties for absorbing vibration because of the presence of the fine graphite distributed in the matrix structure. This makes possible quieter and smoother running machinery and a longer service life. It also prevents a building up of harmonic stresses which may affect the accuracy of the machine. To illustrate, the author knows of some frames made of high-strength gray iron cast from the same pattern that was used for steel that, under full load and when cold forming nuts, showed an elongation of 0.023 in. in the steel castings and only 0.003 in the high-strength gray-iron castings. Furthermore, the steel frames showed effects of fatigue after forming 10,000,000 nuts whereas the original accuracy was still maintained after 40,000,000 nuts with the high-strength gray-iron frames. In this case the difference in service is not due to a difference in strength or modulus of elasticity but must come from an effect of damping, and illustrates the important consideration that engineers should give this property in gray iron.

Wear resistance is an outstanding characteristic of high-strength irons as a result of the close sorbo-pearlitic character of the metal matrix in which are distributed the fine particles of graphite. The general acceptance of automotive engineers of high-strength gray iron for brake drums is also proof of this outstanding property. It should constantly encourage engineers to a larger use of this iron because of its wear-resistant properties.

Compression strength is high in high-strength gray irons and runs up to as much as 165,000 psi. Compression strength has always been recognized as an outstanding property of gray iron, and this is an even more important property in the high-strength irons.

The stress-relieving and damping properties of gray iron are shown in the high fatigue values that characterize the modern high-strength gray irons. As evidence of the importance of this property to engineers, one has only to mention the astounding results that have been obtained with crankshafts and camshafts. In fact, practical tests with high-strength gray iron and steel crankshafts with the center bearings offset $^1/_{16}$ in. have shown the gray-iron shafts to operate several times longer than the steel shafts before fatigue failure.

The yield point of gray iron is near the ultimate elastic limit. Machines made of high-strength gray iron will run accurately, because it takes a large overstress to break the part. This overstress is considerably higher than the yield stress of many competing materials.

Other properties of high-strength gray irons can be summarized as follows: modulus of elasticity 20,000,000 psi and better; ultimate tensile strength 50,000 to 60,000 psi; transverse load on 1.20 diameter standard test bars on 18 in. centers,

3000 to 3800 lb; torsion impact up to 36 ft-lb, or double ordinary gray iron; izod impact with notched bars 2 to $2^1/_2$ ft-lb, or about double regular gray iron; Brinell hardness 200 to 240 as cast, 260 to 600 heat-treated.

There is one other important property of modern high-strength gray irons that engineers should become more familiar with because of its importance. This iron can be heat-treated by quenching and drawing much the same as one would treat a piece of tool steel. By this heat-treatment, hardness, anywhere up to 500 Brinell, is easily obtainable and the tensile strength and other important engineering properties are greatly improved if the heat-treating is properly done. The tensile strength increases to values of 70,000 to 80,000 psi.

In some applications this hardness produces parts of extremely good wear resistance, in fact, better than any other material known, including the finest alloy steels. In other parts it is advisable to draw the castings back to maximum machinable hardnesses so as to get the higher strengths consistent with best wear resistance without resorting to finish-grinding. This heat-treatment is of particular value in such parts as cams, gears, cylinder liners, rams, and disks for heavy-duty work.

It is believed engineers themselves are holding back progress in gray iron by not properly recognizing the advances made in the industry and specifying what they want on their drawings. On nine out of ten drawings where gray iron is specified, the designer simply calls for "cast iron." The purchasing agent will generally buy at the cheapest price, and as it costs less to make low-strength poor irons than high-strength irons, the parts purchased are most likely made of the poorer iron. Consequently, engineers complain about the lack of progress among gray-iron foundrymen! Then, many times the drawings are for machines to be built in jobbing machine shops and as poor gray iron machines more easily and faster than higher-strength gray irons, these machine shops will probably furnish a low-strength cast-iron. In other words it is more profitable to use the poor grade of iron.

In the interest of the foundry industry and also in the interest of engineers, therefore, the plea is made that engineers specify gray iron for the service they want, see to it that the product is coming from responsible manufacturers, work with them and consult with them on design and specifications, and then venture to work into design high-strength gray irons, taking advantage of progress that has been made in the metallurgical and physical properties of this useful metal.

Malleable Iron Castings

BY ENRIQUE TOUCEDA AND J. H. LANSING

MALLEABLE FOUNDER'S SOCIETY, CLEVELAND, OHIO

THE ADVANCEMENT in the manufacture of malleable iron during the last 20 years is a flattering testimonial to what the malleable-iron producer has been able to accomplish, and particularly is this the case when the extremely narrow margin between cost and selling price, with which the industry has operated, is taken into consideration. In addition to this, in not a single instance has an attempt been made by any consumer to have the specifications raised, each increase having been promulgated by the industry itself. A comparison of some important elements of the original and present specifications should be of interest.

The first specifications for malleable iron recorded in the Transactions of the American Society for Testing Materials (A47-04), bearing the date 1904, called for both a tensile and transverse test (the latter is a test used for brittle materials and, therefore, not properly applicable to malleable iron), the tensile bar being 1 in. square and 14 in. long. The minimum tensile strength specified was 40,000 psi, and the elongation measured in 2 in. was stipulated at not lower than 2.5 per cent. The transverse strength stipulated 3000 psi with a minimum deflection of 0.5 in. In the composition of the metal, sulphur and phosphorus were not to exceed 0.06 per cent and 0.225 per cent, respectively.

Many changes were made in the specification in the years which followed, in 1924 the present standard tensile-test bar with an over-all length of 7.5 in., with grip ends 2.5 in. long and 0.75 in. in diameter, a gage length of 2.5 in., and a diameter of 0.625 in. being adopted. At that time minimum tensile strength and elongation were specified at 50,000 psi and 10 per cent in 2 in., respectively.

Current specifications established in 1933 cover two grades of malleable iron as follows: Grade 32,510 has a minimum tensile strength of 50,000 psi, a minimum yield point of 32,500 psi, and an elongation of 10 per cent in 2 in.; and grade 35,018 has a minimum tensile strength of 53,000 psi, a yield point of 35,000 psi, and an elongation of 18 per cent in 2 in.

It is obvious that the mechanical engineer is most interested in the suitability of malleable-iron castings as a component part of a machine or structure. As it happens that one of the authors of this paper is an engineer, the properties that he personally would investigate, if it were up to him to decide just what character or type of casting he would select under different conditions which naturally can vary to a considerable extent, are briefly discussed in what follows.

In this discussion comparisons of malleable-iron castings are made with other products in cases where competition between the materials is on a price basis.

ADVANTAGES

Under these circumstances the engineer would need to satisfy himself on the following points:

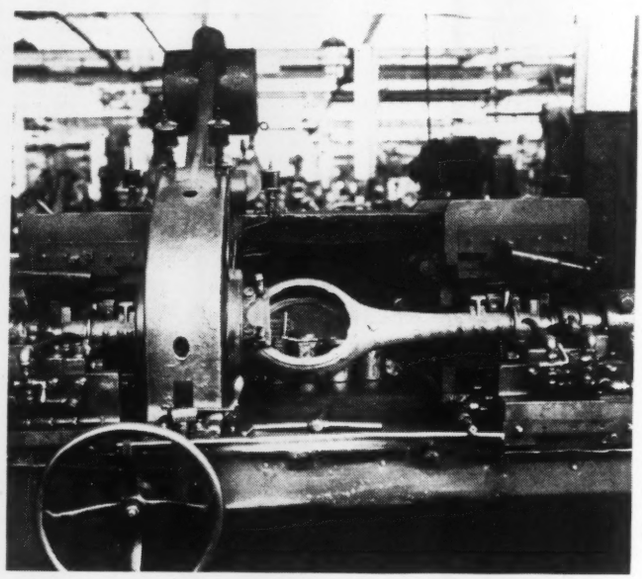


FIG. 1 MACHINING OF MALLEABLE-IRON AUTOMOTIVE REAR-AXLE HOUSING

(On a center-drive lathe, both ends of the castings are roughed and finished. This operation consists of turning and facing flanges, dust shield, and felt.)

Machinability. Will the castings have to be machined? If so, there is no ferrous product, equal to malleable iron in mechanical properties, that can be machined with equal ease. If it is a question of production, therefore, and keeping in mind consistently high yield point and elongation, the malleable-iron casting is the one he would select.

Safety Factor. Obviously, the engineer designer in deciding what safety factor to use should not be governed solely by the mechanical properties, but take into account the probable presence of hidden defects and allow for them. Aside from occasional minute particles of manganese sulphide, nonmetallic impurities are rarely present in malleable iron, and blowholes are of rare occurrence. The hard iron, be it from the open-hearth, the electric, or the air furnace, contains on an average 1.00 per cent of silicon, 2.35 per cent of carbon, and 0.28 per cent of manganese. Thus, while the steel man has to add deoxidizing agents to the metal prior or subsequent to the tapping of the metal from the furnace, this precaution is not necessary in the case of malleable iron, for the protecting elements are in the bath when it is tapped. The iron is superheated for the pouring of the molds at a much lower temperature in the case of malleable iron than in the case of a metal having a much higher melting point, and consequently the presence of blowholes in the former is a rarity. Blowholes can and do at times occur in malleable-iron castings, but when they are present either the pouring temperature has been too low, when these will appear close to but under the skin, or their presence is due to a sand heap that was too wet. Such castings are invariably scrapped either in the hard-iron stage or in final inspection.

Yield Point. In the authors' opinion the safety factor had best be based upon the yield point rather than upon the ultimate strength. The average yield point of malleable iron is somewhat over 35,000 psi. Many bars run as high as 38,000 to 40,000 psi. At a sacrifice of a slight reduction in elongation, 42,000 psi can be guaranteed through the introduction of about 1 per cent of copper.

Grain Size. In any casting, fineness and evenness of grain size constitute a structural condition that is highly desirable in order to insure toughness under impact. Owing to the temperatures at which the annealing of the castings takes place, the grain size in malleable iron can neither be coarse nor uneven, and this condition is obtained without effort on the part of the manufacturer.

Internal Strains. Locked-up stresses can and have been the cause of many premature failures. All malleable-iron castings are free from such defects, for in the annealing process the castings are cooled gradually and very slowly within the critical range and subsequently until the anneal has been finished. Not only is premature failure invited if these defects are present, but sight should not be lost of the fact that rusting is accelerated where internal strains exist, a fact with which every bridge engineer is acquainted if he has had occasion to inspect a bridge that has had to be repainted.

Stiffness. The modulus of elasticity, the unit stretch within the elastic range of malleable iron is 26,000,000 psi. While this is not as high as obtains in the case of steel, the fact remains that stiffness depends also upon the design of the part. For component parts that are to be subjected to severe impact in service, and the bulk of malleable-iron castings are used under these conditions, a modulus of 26,000,000 psi is high enough and better under such conditions than would be one of 30,000,000 psi, that is, the former in case of sudden overloads has more of a chance to act as a shock absorber than the latter. If stiffness is found to be lacking, it can be taken care of in the design of the part.

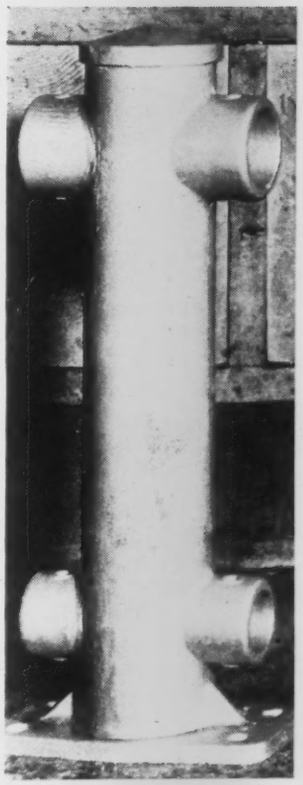


FIG. 3 ONE-PIECE MALLEABLE RAILING POST WEIGHING 130 LB

(Post is $6\frac{1}{2}$ in. outside diameter, $3\frac{1}{2}$ in. high, with a metal thickness of $\frac{1}{2}$ in. In malleable iron it replaces a post made up of a 5-piece pipe and casting assembly.)

Design. A great deal can be said on the subject of design. Poor design is accountable for a great deal of trouble for the producers and consequently for the consumer. The subject is too big to form a part of a short paper. The engineer designer, obviously, knows the theory of structures; he can make a more or less accurate estimate of the sectional areas necessary to accommodate the tensile, compressive, and shearing stresses to which the part will be subjected; that is, he is familiar with the stresses and strains, but he is not familiar with the distresses and pains to which the foundryman will be subjected after he has received the pattern.

To avoid trouble and delay, the engineer designer should submit his design to the foundry in order that it can pass judgment as to whether the design is so detailed that shrinks will not show up in the casting and cracks will not be likely to occur, and in order that the casting can be properly gated and fed. The ability of molten metal to flow ceases within a few seconds after the metal has filled the mold void. Both the pouring sprue and the feeder will act as a reservoir of molten metal to accommodate the space resulting from the change in volume of molten to solid metal that takes place progressively. Obvi-

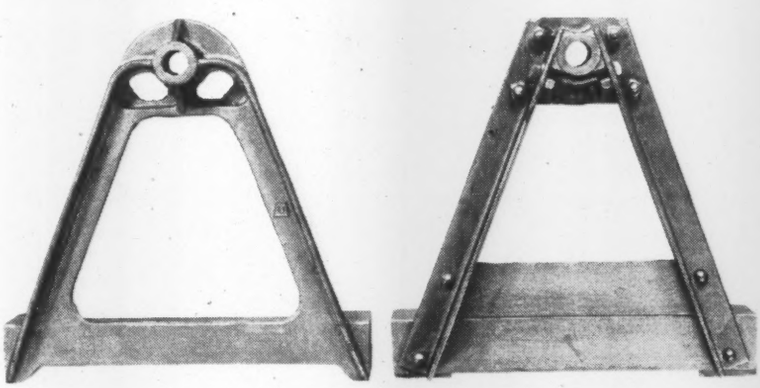


FIG. 2 MALLEABLE-IRON CASTING REPLACES ASSEMBLED UNIT

(The malleable-iron casting replaces an assembly consisting of six rolled-steel angles, one gray-iron casting, one specially bent bolt and nut, four machine bolts and nuts, and four rivets, and the drilling of 26 holes is eliminated. The weight of the casting is 11.75 lb while that of the assembly is 19.25 lb.)

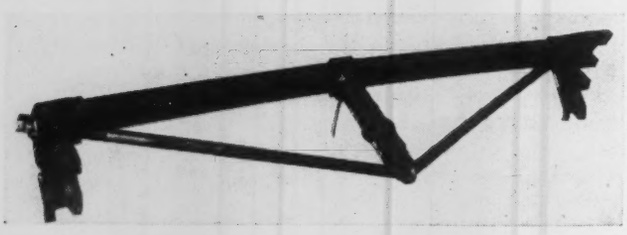


FIG. 4 MALLEABLE-IRON BRAKE HEADS AND FULCRUM IN RAILROAD BRAKE-BEAM ASSEMBLY

(Hundreds of thousands of malleable-iron brake heads and fulcrums are in the use illustrated, and have for years demonstrated their serviceability in this severe and important application.)

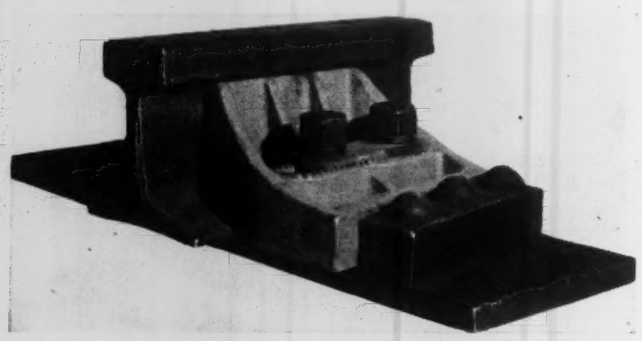


FIG. 5 ADJUSTABLE RAIL BRACE

(Adjustable rail braces of malleable iron fit the web and top of base of rail, firmly holding and bracing it. Resistance to repeated impact and to corrosion are factors in this application.)

ously, if the casting is to be sound, feeding must continue uninterruptedly as solidification progresses, which, for example, would not take place if a certain detail part of the casting were of such a thinness that freezing takes place so quickly that molten metal from either reservoir cannot reach some part of the casting that still needs more metal for complete soundness.

Corrosion Resistance. No one acquainted with malleable-iron products will question the fact that castings in this material are more resistant to atmospheric corrosion than is the case with competitive metals. In a paper written for The American Society of Mechanical Engineers by one of the authors,[1] various photographs are shown of parts made up of steel and malleable iron that had been exposed for years to the weather and to wet and dry conditions. In the A.S.T.M. and A.F.A. symposium on malleable iron, which gives results of comparative tests made by Wolf and Meisse on samples subjected for many years to locomotive smoke, the fact is demonstrated that under these conditions malleable iron is much more rust-resistant than the products with which it competes. Inasmuch as the matrix of malleable iron is wholly ferritic, it should be anticipated that its corrosion resistance should be superior to the other products.

Impact Test. The consulting engineer of a group of 73 plants comprising the Malleable Founders' Society, does not believe that any of the notched-bar specimens show reliable results when applied to malleable iron and prefers the use of a specimen that is not notched. A description of this test is given in the A.S.T.M. and A.F.A. symposium.

It would appear to the authors that, based upon facts which they believe cannot be questioned, for castings for parts of machines, varying from several to 700 lb, the selection of malleable iron is justified.

The metal has a consistently high yield point, and more than ample ductility for safety, as measured by the elongation, and it can be machined at a much higher cutting speed than any of its competitive products of equal mechanical properties. As manufactured the castings have a uniformly fine grain size without subsequent treatment; they are free from internal strains; they have a structure which is cleaner than obtains in the case of competitive products; and the metal has a stiffness, as measured by its modulus of elasticity, that is a better insurance against failure under shock than the higher modulus of competitive products. The casting surface can hardly be bettered; corners are sharp; and as demonstrated in a paper written by one of the authors for the A.F.A.,[2] when riveted the rivets are much less liable to become loose in service than in the case of steel.

DIRECT APPLICATIONS

To convey an idea of the form in which two thirds of a million tons of malleable-iron castings went into use in 1936, with a somewhat greater tonnage being produced in 1937, a few typical illustrations are included.

Malleable iron is largely specified as an automotive construction material. Its toughness and shock resistance, combined with the facility with which it may be machined, have made its contribution to the success of the present-day automobile an important one.

In railroad-car construction, malleable iron is used in the construction of locomotive and passenger-, freight-, tank-, and refrigerator-car parts, including such elements as brake heads and fulcrums, combination push-pole pocket and corner castings, side bearings and braces, hand brakes, door fixture castings, draft gears and attachments, and in track jacks, track and switch castings, adjustable rail braces, and, largely, in handrail posts.

In addition to the automotive and railroad uses, malleable-iron castings are used extensively in farm implements, highway and bridge guard railing, detachable chain, high-tension insulator castings, and many other general applications.

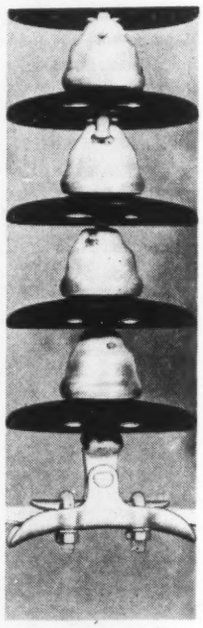


FIG. 6 MALLEABLE-IRON HIGH-TENSION INSULATOR CASTINGS

(In this application malleable iron is specified because of its ability to withstand a load of 25,000 lb without failure and all kinds of atmospheric conditions, including locomotive smoke, salt air, ice, sleet, and hot sun.)

CONCLUSIONS

In conclusion it may be said that the material with which this paper deals is subject to a continual check by the malleable-iron industry's research organization. Tensile tests are regularly made on the product of member plants and regular inspection of shop practice and product is made by the organization's representatives. This is in keeping with, and in continuation of, the earlier mentioned industry policy of taking the lead in raising the standards to which malleable iron must be maintained.

[1] "Malleable Iron as a Component Part of Machines and Structures," by Enrique Touceda. Presented at the A.S.M.E. Annual Meeting, December, 1932.

[2] "Resistance of Malleable Iron to Repeated Impact Stresses of Machined and Unmachined Malleable Castings," by Enrique Touceda.

ENGINEERING'S PART *in the* DEVELOPMENT *of* CIVILIZATION

VI—Present Relations and Future Outlook for Civilization in an Engineering World

By DUGALD C. JACKSON

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

WHILE summing up the present relations and glancing at the future outlook for engineering and civilization, we must remember that future events are partly molded by events that have gone before. Future events are like pebbles at the bottom of a fast flowing river. They are being and will continue to be molded by the streams of intelligence which flow from the past into and through the channel of the present. They are being, and until they arrive at their proper place in Time will continue to be, still further modified by the waters flowing from our own wells of intellectual and physical activity, and by streams from similar wells which will open in the future.

We must further recognize that nature works changes by each of two ways—by slow evolution and by mutation. Sometimes each of these operates in its own sphere and alone. Sometimes they operate jointly in the production of results. These processes apply as fully to social growths as to primroses and sweet peas. The mental world, as a whole, changes only very slowly. If this were not so we would already have reached a more gracious state of mutual serviceability and comfort. But the mental world does change under experience, as we have seen from the expositions of the other lectures.

I will lay before you, for emphasis, another illustration in which the change is purely mental: Old-time unconditional reliance on the declarations of oracles and the interpretations of omens came to be modified according to the righteousness or wickedness of the persons requesting guidance. Originally, such outpourings were accepted by superstitious peoples as being fully authentic. Then, in an intermediate period, the display of a good omen might not assure success if observed for the affairs of a bad man, while a bad omen might not stand in the way of a happy outcome when observed for a good man. And now, among educated men in the western world, we have largely ceased to regard seriously any omens of the old-time character. The rabbit's foot in the pocket and knocking on wood still hold a place, but among most educated people only in a humorous or Pickwickian sense. Thus the mental world changes with education and experience.

MAN'S THINKING IS INFLUENCED BY FALSE DOCTRINES

Perhaps that exceptional mental phenomenon called genius arises in men by a process analogous to mental mutations. Few men can formulate conceptions of breadth by the light of their own narrow experience; but the adventures and emotions of the race are multifold and an individual now and then arises who marshals his own experience alongside of that observed in others and thereupon is able to lead the way to new and hitherto unformulated ideas or things of value to civilization. Such men often are in advance of their times and find that their ideas meet a discouraging reception among people at large; but from them may come unpredictable proposals of great worth, and a forward looking commentary, such as this lecture, cannot undertake to foresee what may come from such a source. It is only the effects of the slow evolutionary process that one can hope to foresee.

With respect to the majority of mankind, Charles Reade ironically refers to the mental status in one of his novels. He says, "In short, it is the characteristic of a certain blunder called genius to see things too far in advance. The surest way to avoid this is not to see them at all; but go blindly by the cant of the hour." Many persons find it easy or expedient to follow this "surest way" and others are incapable of rising above blindly following after "the cant of the hour." For such people a well-phrased slogan has a compelling force which a critical examination would show to be undeserved. Such people, nevertheless, are intellectually competent when fully informed, and to their slowly modifying aspirations we must credit most of the evolutionary progress in engineering, civilization, and ethical principles. In looking forward we must have the great multitude of such people and their influence in mind and make our interpretations accordingly. We find that progress is being made.

Politics are seldom free from the smell of false slogans, the unsoundness of which would be exposed by exacting analysis. We of this country are now suffering from the effect of many partially or wholly false slogans that relate to the fields of politics, engineering, education, and security, which have been formulated to satisfy this slogan hunger of the majority of mankind. For example, we hear in frequent repetition the doctrine that civilization is on the route to decay. This doctrine, however, is founded on an incorrect interpretation of history and an incorrect definition of the word civilization. It improperly assumes that civilization is a consequence arising from important inspirations of sentimental character and that intellectual culture is its measure. There seems to have been a reluctance to adopt the truth that civilization is born out of the association in amity of many people, and that it therefore is the direct co-relative of engineering which makes possible community security in living. There appears an equal reluctance to recognize that intellectual culture is a child of leisure such as may accompany a high civilization, instead of being a measure of civilization.

The false doctrine that civilization is decaying has been asserted again and again over the thousands of years of history, from several thousands of years ago to the present time. Men-

Last of a series of six lectures on this subject delivered at the University of North Carolina State College of Agriculture and Engineering, Raleigh, N. C., Jan. 21 to 29, 1938.

cius, who lived before the Christian era opened, wrote, as I have previously mentioned, that the world had fallen into decay and that right principles had dwindled away. If decay had in fact been going on during this long period, as thus again and again is asserted, there would be mighty little civilization left with us today; instead of which condition we have in the best parts of the Western World a civilization which is superior, in the sense of being more comprehensively helpful to mankind, than that which existed anywhere in any preceding century.

Let us look at this from the standpoint of comfort and happiness of all the people. It is not necessary to consider in detail the ultra-wealthy, the ultra-ostentatious, or the ultra-extravagant citizens of our nation or of other nations. They are a small proportion of the whole number of citizens. If they do not enjoy as much happiness as characterized their counter-parts of former times, such as two centuries or twenty centuries ago, it is probably their own fault. Observation shows that many of our contemporary ultra-wealthy fellow citizens secure great happiness in unostentatious, non-extravagant lives of helpfulness to their fellow men. Those citizens have learned wisdom, and, as Sophocles said long ago, "wisdom brings happiness."

Now, as to the rest of our fellow citizens and ourselves, with our tilling of the soil, our unskilled and skilled artisanship, our activities in commerce and finance, our occupations in industry, our practice of the professions, what of our counter-parts in past time?

CIVILIZATION BASED ON ENGINEERING HAS IMPROVED THE COMMON LOT

Considering the conditions of three hundred and fifty years back, the answer is that a good many of us would have been on the basis of villeins, serfs, thralls, or peasants living a life of now almost unimaginable sordidness and squalor, on little if any better (and sometimes less) than a subsistence basis, and subject to disease and abuse. Most of the rest of us would have been carrying on for ourselves, but in a relatively sordid and insecure way. No comparison of happiness can be drawn which would raise that of the old times to parity with that of the present, unless it should be asserted that the lower order of education prevented the old-timers from being critical of their level of living and left them substantially without ambition to change that level. However, even that would not heal the wounds to contentment caused by the overhanging fear of stalking disease and harsh treatment occurring in former times. One gets an erroneous impression of these things from ordinary reading. Most historical treatises and essays treating of affairs of two to four hundred years ago, and most of the books of fiction written in those times, deal with people of power and wealth, or at least of independent means, and say but little of the lives of the submerged majority. The reader therefore is likely to obtain but slight glimpses of truth regarding the latter, unless he intentionally seeks out the unusual books which illuminate the subject.

Two thousand years ago the conditions were much worse than they were three hundred and fifty years ago. Indeed, a majority of the inhabitants of many of the so-called civilized areas would have been driven slaves two thousand years ago, and most of the remainder would have been non-citizens subject to arbitrary harsh treatment or have been citizens despised and ill-treated because of being in trade or for some other now obsolete cause. In former centuries the peasants of northern countries labored incessantly, under the lash of necessity, in their struggles with nature toward securing agricultural production. They were fed, clothed, and sheltered year by year in proportion to the success of their struggles, which sometimes afforded a meager plenty but often yielded only paucity or famine.

In more recent years, means for easy communications and the disseminated use of an intermediate token agency (money), which has encouraged the exchange of goods, have tended to average up conditions by encouraging thrift and commercial exchange. On this foundation, the influences of accumulating science have been able to work for the betterment of conditions of living. In the older days of peasant struggle, sympathetic contact seems to have been limited to neighboring individuals; but the advent of easy transportation of men and goods, quick intercommunication of thought, and spread in the use of money have brought entire communities and nations under the spell of mutual helpfulness. This attitude woefully breaks down at times, but its tendency is nevertheless well established.

Moreover, if we look at the situation from the standpoint of moral relations between individuals and between groups, and if we hold the opinion, as most of us do, that established moral relationships contribute to happiness, then it seems to me that we must admit our notable advance over earlier centuries, of both the near past and antiquity. The admiration which the ancients of several thousand years ago directed toward cruelty, trickiness, and immorality, when successfully carried out, is illustrated by their traditions regarding the individual lives of the gods whom they admired as well as feared. Primitive people are hysterically and inherently cruel on account of their ignorance; and much of the cruelty of later ages, down to the present day, is part of the cloak of habit which has come down from primitive ancestors to us through all the ages of gradually advancing civilization. We may hope for the ultimate dispersal of this remnant habit, although a habit often maintains its hold on human beings long after being condemned by the intelligence.

To complete this examination of conditions in past times, perhaps we should also look back over a period of two to four generations instead of centuries. Therefore let us look back two generations from mine. That presumably is three generations for most of the readers of MECHANICAL ENGINEERING and perhaps four generations for a few. My grandfathers were both among the fine type of stable, independent farmers found in the fertile area of southeastern Pennsylvania. During my boyhood I spent much time, year after year, in the families of my grandparents, thereby becoming well acquainted with the lives and the aspirations of themselves, their acquaintances, and in general of the farm people in their neighborhoods of northern and southern Chester County. Moreover, I was a village boy, which resulted in further intimacies with the modes of life and the aspirations of country people. They were an upright, contented, and happy people who accepted without murmur numerous discomforts, hardships, and sorrows, many of which have been lifted from the shoulders of corresponding people of today by the outcome of various agencies, important among which are engineering industry, sanitation, and preventive medicine. I am sure that people of corresponding situation today enjoy more comforts and leisure, and are fundamentally as happy as those people of my grandparents' time. Happiness is psychological; but, if suffering fewer hardships, possessing more leisure and more education, and yet maintaining productivity, conjointly contribute to happiness, then the people of today are in fact happier than the corresponding people of a couple of generations back.

My birth near the end of the war between the States gave me a childhood acquaintance with the bitternesses which for a period survived the end of that war. That the bitter rancor that always follows destructive civil war was dissipated and converted into friendship and cooperation among our great

population, in half the life time of one man, is a tribute to the strength of mutual sympathy and intellectual tolerance that, arising out of intimate mutual contacts, is now a notable part of western civilization. I have talked with numerous men of my generation and believe that we are usually in agreement regarding the high level in human ethical conduct which this exhibits. Great Britain and other nations have had similar experiences in the more distant past.

IMPROVEMENT IS ALSO NOTICEABLE IN INTERNATIONAL RELATIONS

In international affairs, we must confess that ethical principles have never been compelling, nor are they of compelling influence now. However, we may justly reflect that vicious war, either within some nation or nations or between nations, was never ceasing in Europe during the seventeenth and eighteenth centuries. In its destruction of people and wealth, and in its imposition of horrors and sorrows on the peoples, war was then perhaps as great an offender in proportion to numbers of populations and extent of wealth within nations as it has been in later wars. However, regardless of the woeful lack of a compelling force of ethics in international affairs, we perhaps should cite an apparent greater unwillingness of western peoples now to enter destructive warfare among themselves as some slight advance in a sense of justice and ethics.

I put this forward for the purpose of indicating that even in these international affairs the world has not slipped backward and perhaps has actually stepped forward toward more enlightened mutual relationships. The patriotism which supports a national idea and is willing to fight for it even to the extremity of death is partly a reflex from the craving for security which is instinctive in man. Convince man that war will not ultimately result in greater security and stability for either him or his nation and the tendency toward organized war will be weakened. Especially will this be achieved if other sufficient routes are kept open on which men's individual love of risk and adventure can be fully expended, while paths to selfish profits during the prosecution of war are closed.

However this may be, the creative engineers of my acquaintance are heartily opposed to prosecuting war wherever it is avoidable. The services of engineering processes and engineering devices have been abused by use in warfare, but to the distaste of the creators of the processes and devices. Such men know that war, besides being inhuman, is tragic, expensive, and inefficient—tragic because of its track of human wastage, hardships, and sorrows; expensive because of its destruction of desirable wealth which may be represented either by money expenditure or property destruction; inefficient because irritating steps and high-handed action, substituted for patience in negotiation for adjusting differences, seldom produce returns comparable with the cost. Here the problem is to get all parties to use wisdom instead of folly, cease irritating acts, and put their differences to negotiation and impartial adjudication. The people of few nations (and those are mostly among the prosperous small nations) seem to be ready for this.

Let me emphasize that I am no Pollyanna. Most of my life has been spent as an active engineer, required to assemble facts as they exist and draw sound conclusions from the assembly. The foregoing conclusions regarding the condition of civilization are, in my opinion, soundly based on facts and are worthy of your attention. I will venture to broadly add one more thought before moving along in our review. It is as follows: Much as I believe that our best interest as Americans lies in living our national life in peace at home and abroad, and moreover that we must economize in our public expenditures or come to grief, it is also my conviction that we cannot be sure of freedom from war unless we continue building a well-planned navy until we are up to the proportions provided for in such naval treaty limits as truly or tacitly exist, and also maintain the training of our army. The diffusion of the advantages arising from engineering has not yet gone far enough to impel the formulation of any sound essence of ethics in international affairs, and it is still usual for nations to interpret for themselves their own momentary and seeming interests as identical with right and justice. We therefore have an obligation to ourselves to be prepared to forcefully repel any unjust invasion of the welfare of our citizens; but, possessing the support of that preparation (the minimum of which I have indicated above), we have the obligation to negotiate in a friendly manner the adjustment of any real grievance alleged against us by any self-chosen complainant. That is the attitude of rectitude, and rectitude is the bone which gives firmness and stature to strength of character such as insures the stability of a nation.

ENGINEERING IS CONTRIBUTING TO DEVELOPMENT OF POLITICAL ECONOMY

Recurring again to the thread of our general review, we observe that since the middle of the nineteenth century, for the first time in the world's history, the peoples of the western world have been in command of knowledge, skill, and natural resources sufficient to produce comfort and satisfaction for every one. Our deficiency is lack of effectiveness in our applications of knowledge and skill. Finding the solution is a joint problem of political economy associated with engineering and opens up possibilities for new threads for engineering and the improvement of civilization. Indeed, every newly discovered fact in science or political economy may disclose the origin of a new thread in the fabric of engineering and thereby affect civilization. An aspect of engineering which primarily arises from a recognition that the dignity and power of the human mind makes it appropriate to relieve man labor by machine labor in drudge work, in order that man may enjoy more leisure although maintaining full productivity, is only now crossing the threshold of its origin. This aspect requires for its correct development all the facts that can be discovered in political economy, just as the older aspects of engineering have needed and have utilized all the facts available from the discoveries in natural sciences.

When left to their own recourse most men love the excitement of risk and the joy of struggle; and through its processes of transportation, electrical communication of thought, development of new products and new operative processes in manufacturing, and improved agricultural processes, engineering has immensely widened the scope and accelerated the pace of man's activities besides expanding his experiences, thus widening the opportunities for risk and struggle. The processes referred to have also provided additional impulses for stimulation of the pocket-book nerves and the ambition nerves of individuals.

Abuses have arisen from the situation. Struggle commonly spells friction or oppression. The evolutionary struggles for existence and for dominance which characterize organic species are usually contests of individuals against all the rest, either as individuals or as groups. The outcome of engineering has, for the human species, ameliorated such struggles while multiplying the opportunities for their occurrence. It also has shifted the impact of mental and physical frictions in society so that there is concentration of frictions at specific points. Consequently, one duty which has emerged for those who are occupied in the field of engineering is to study the social frictions and to endeavor to remove their causes by suitable inventions of either physical or ethical nature. That security and comfort

of living are increasing among civilized peoples is shown in manifold ways. For example, the extraordinary increase of population which has been apparent during the last hundred years in industrial countries is one of many objective proofs, which proof, as such, is quite independent of the question of the desirability or undesirability of dense populations. There is no ground on which to establish arguments for the overthrow of our present fundamental processes of democracy, but it is our duty to strongly endeavor to eradicate abuses in their practice.

This country, unfortunately, is now troubled by a cult expressing the doctrine that social frictions can be prevented by legislation, both general and specific, whereby man's love of adventure, love of risk, and personal ambitions shall be restrained. History of government in Europe, and our own national experience, show that educated men's wishes and their acts arising therefrom cannot be restrained in a democracy by general legislation unless its objectives and its measures appeal to the intelligence of the people. This is in accord with the fundamental qualities of the human mind. Even specific legislation which does not appeal to the common sense of the population soon loses its influence. I cannot here take time to illustrate the truth of these observations, but history of public legislation and administration fully bears out the principle.

The principle, unhappily, is now frequently violated in our public affairs. This violation goes even to the extent of withholding from public knowledge critical reports made by highly respected and competent experts on technical matters about which legislation is planned, with no apparent object other than to make it easier to persuade legislative bodies to enact politically determined legislation of which the ultimate value lies under a cloud of doubt. Some of such legislation is likely to turn as sterile as an alkali desert and, because of its costs, perhaps ultimately become as bitter. We may well ask ourselves the question: Does the dignity of the human species in a civilized nation reasonably admit of a government which declines to be subjected to constant exacting analysis of its purposes; and can such a government be truly serviceable to the governed? A sentiment written by the poet Wordsworth is applicable to this point,

> Him, only him, the shield of Jove defends
> Whose *means* are fair and spotless as his *ends*.

CRITICS OF CIVILIZATION FAIL TO TAKE CORRECTIVE MEASURES THAT ENGINEERING METHODS PROVIDE

Complete freedom of thought and action, restrained only enough to prevent imposition by individuals or groups on other individuals, is the most precious possession of democracy, because it is the only guarantee of independence from oppression. As Stephen Duggan has recently said in question and answer: "Why Democracy? Because Democracy is based upon a respect for personality as the thing most worth while in life." It is to be noted that poverty of life for the multitudes in India (a country with relatively little development of engineering) goes hand-in-hand with failure to recognize the dignity of the man-hour compared with the animal-hour when applied to service.

The defects in human relations which arise are attributable neither to faults in the fundamental ideal of a complete civilization nor to engineering which has set up and continues to maintain the stage for a possible realization of that ideal. The seat of the defects is actually under the hands of civilization's critics. These critics talk much, but fail to agitate constantly for the development of honest mutuality up to the limit of possible conditions for the times. Such agitation does not consist of whipping up a sentimental benevolence—there is truth in the old saw that overworked benevolence may be weakening instead of helpful in its effect—but it does mean an effort to produce an honest and helpful sympathy between people, accompanied by a sentiment of the relative fitness of things. It is proved that this is not being fully accomplished, for example, when a post of a highly respected and useful patriotic organization, located in a municipality near Boston, permits the body of a well-known crook and racketeer who had been murdered by a fellow racketeer to lie in honor at its headquarters because he chanced to be a member of the post. So far as I have learned the membership of the post gave no sign of protest against this misuse of an acknowledged mark of honor and several thousand citizens from that community (it is reported) filed past the bier, either led by curiosity or out of a false respect for the crook.

The fault that results in such things does not lie with civilization nor with engineering, but a very grave responsibility lies on the critics who are failing in the call for agitation and education to bring the public to a realization of the relative fitness of things. This is a personal and group matter for prosecution. It cannot be accomplished by legislation.

I assume that we all will agree that poverty should be eradicated, if practicable in the face of human individual characteristics, because it is sentimentally an unfair condition in which to allow human beings to sink, and, more practically, because it drives men by pain into all sorts of lawless and shameful actions. As I summed this up several years ago: The educated or brilliant man who is destitute through no reprehensible fault of his own is a menace to organized society; the uneducated and meager-minded man who is destitute is a continuing cost burden to society; and it is a poor order of intellect which can look upon the poorhouse as a desirable haven for old age. Nowadays there is much loose and uninformed talking and equally much volatile thinking which has no foundation in experience; but we will not reach a balanced state of affairs until we get together in heart-to-heart discussions often enough to bring ourselves under the conviction that increase of real wealth is secured only by means of humanly directed effort applied to nature, and that the security of life and livelihood out of which civilized society springs is obtained only by human exertion. The man who churlishly declines to exert his best efforts during reasonable working periods, and the man who "lazies" on his job so as to curtail production in the honest belief that he thus improves the stability of employment for himself and his fellows, equally contribute to maladjustment and do not contribute to the interest of themselves or of society.

ENGINEERING HAS FOUND SUBSTITUTES FOR EMPIRICISM

Much has been accomplished in this long-time development of civilization. Much is yet to be accomplished. Engineering itself, on the continuing achievements of which the development of civilization has rested and must continue to rest, is finding new courses even in its oldest branches. To illustrate this I will quote from an editorial comment taken from the organ of the American Society of Civil Engineers, which says:

> Earthwork engineering is older than history itself, but scientific earthwork engineering is just now coming of age. Twenty-odd years ago the precepts of foundation design might have been epitomized thus: "Identify the soil; select a bearing value; make a loading test on a small area if necessary; when in doubt use piles." Today the foundation engineer does not think of "bearing value" in the traditional sense; he takes the results of loading tests with a grain of salt; he knows that piles in certain cases may be detrimental. In short he has forsaken rule-of-thumb procedure for the scientific approach made possible by soil mechanics.

Unhappily our sociologists and economists, being sentimental and very impatient, but no more sympathetic than engineers, propose, and even proceed, metaphorically speaking, to put

piles where piles ought not to be put, and the result does not contribute to actual progress.

Education, discussion, examination of experience disclosed in the past, and examination of present abuses and their causes, all brought impartially into the comprehension of all people of a nation, comprise the one hopeful process in the aid of progress. It is an inherently slow process which cannot be overhastened with safety. Any effort to press forward beyond a point acceptable to the intelligence of the people is a false effort because it carries with it the germs of harm. Such effort is hurtful to the best aspects of the mutual relations on which civilization depends, and ultimately is a retardant of both engineering and civilization, which we need to carry forward coordinately with each other if we are to progress soundly.

Sound progress connotes aid in bringing forward those persons who need aid. It also connotes unrestrained encouragement of the practices of those who are competently proceeding, with ethical consideration, along their own courses. Unless American politicians can be brought once more to follow these tenets, instead of following the urgings of professional reformers, we will be justified in replacing lightheartedness by pessimism regarding our human affairs in this nation.

A NEW CORRELATION OF ENGINEERING AND POLITICAL ECONOMY IS NEEDED

The solution of the conjoint problem of engineering and political economy, which is required to provide for men the craved advantages of convenient livelihood plus leisure that may be obtained from our civilization which has developed on the base of engineering, is a solution which can be secured only by applying the same exacting, unremitting, and critical research that has characterized the unfolding of physical science and its applications in engineering. Much reflection on the question as to where such research can be first established with firm expectation that results suitable to the conditions in this country may be realized, leads me to the answer that certain of the engineering faculties of the educational institutions of this country will have to be relied on, working in cooperation with the faculties of economics and sociology. An intimately cooperating but semi-autonomous group, bridging between the two departments, would be needed to centralize the work.

To go side-by-side with this (and without interfering with any desired treatment by the economists of classical and historical aspects of economics), economics should be taught as an interpretation applied comprehensively to the material aspects of our times, instead of, or in addition to, relying on personal philosophies of what the times ought to be like or treating the subject in subdivisions. Also, we now rely too deeply on the philosophies of the old masters of economic learning who were distinguished interpreters in their own times but had no possibilities of seeing the conditions of our times.

If we in this country are to enlarge and more uniformly distribute our comforts and conveniences, so as to approach closer to a full civilization, we must rely on ourselves for developing sound tenets of political economy, extending scientific research, encouraging invention, and improving conditions for the production and also the distribution of industrial and agricultural commodities. To secure the desired result we must turn to the method of direct attack by competent research, in a manner analogous to that used in the physical aspects of engineering. We need to dovetail engineering into political economy so that they may soundly influence each other, as has been done so well with engineering and the physical sciences. Our present cut-and-try process associated with inspirational reliance in the field of political economy is too uncertain and in the long run is sure to prove extremely costly.

RELATIONS OF FULL CIVILIZATION TO EDUCATION AND ENGINEERING

Now I will return to definitions and ask, "What is full civilization?" And I will answer that it is the condition when all individuals possess, and sustain by their modes of living, an education which realizes Herbert Spencer's old touchstone of the features of full education from self-preservation to social recreation. As Spencer suggests, the educational features may be arranged naturally in the following groups:

1 Those activities which directly minister to self-preservation.

2 Those activities which, by securing the necessaries of life, indirectly minister to self-preservation.

3 Those activities which have for their end the rearing and discipline of offspring.

4 Those activities which are involved in the maintenance of all proper (including ethical and sympathetic) social and political relations in all mutual contacts.

5 Those miscellaneous activities which make up the leisure part of life, devoted to the gratification morally of the tastes and feelings and providing links for gracious companionship.

Who will contest this definition in its general significance? Acceptance of it, however, makes a distinction from the famed cultural civilizations of ancient classical ages, because with them only a minority of individuals could participate in the gracious features of the culture and the excluded majority were held as commoners or slaves. The idea of general community of interests and sympathy was then not yet abroad, and the engineering facilities of those days probably were not sufficient to enable all to be supported on a high level of living. The wide dissemination of Christian ethics has done much in support of the idea of general community of interests and sympathy, and the improvement of engineering facilities has sustained its practicability, but we are not yet by any means at the pinnacle of civilization. Efforts at self-preservation, both direct and indirect, and at parenthood, that is, the first three of the aforestated groups crudely applied, were factors in the lives of primitive man. But the last two of these groups could only come over the horizon along with community life and the continued development of engineering facilities. These two, and particularly the fourth, can be greatly strengthened in their influence on our living by the educational research processes just described.

The French historian and statesman, Guizot, who lectured about one hundred years ago, utilized more than 60 lectures in his masterly disclosure of the history of civilization in Europe and in France *per se* for the period extending from the fall of the Roman Empire to the French Revolution. I have had the need of telling you in six lectures regarding the entire progress of civilization since it arose with community living, and the relations of that progress to the unfolding of engineering. In comparison with Guizot's exposition, these six lectures make only a sketch. But I hope that I have succeeded in showing to you that civilization gained its birth out of facilities provided by a then newly conceived engineering; that civilization has grown, and has become sweeter, as the ages have rolled on and engineering facilities have been extended; that rashly applied efforts to overspeed improvements beyond the standards of thinking of the people ultimately defeat their own ends; and that our alarm should be strongly stirred as we observe that ethical progress is retarded or even arrested in certain European nations by over-domineering political methods which are there being applied. If it has been my fortune thus to succeed and also to have convinced you of the way to proceed in needed additional aspects of research and education in engineering and political economy, then my objective is reached.

"THE INDUSTRIAL WORKER"

Review of a Study of the Effect on the Worker of Physical Factors and Social Situations in the Workroom

By EDWARD R. LIVERNASH

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE STUDY of social attitudes suggests scientific inquiry of a singularly difficult nature. Professor Whitehead's analysis[1] of the Relay Test Group at the Hawthorne plant of the Western Electric Company demonstrates the use of a technique which gives new significance to these social concepts—a significance which extends beyond the statistical relationships found in the data of the experiment, and even into situations in which his particular statistical techniques would not be applicable. The significance of the analysis arises to a considerable extent from the reality which has been given to the concept of social attitudes in a particular situation, thus enabling us to orient our thinking about group motivation in terms of the mutually interdependent effect of different policies, practices, and environment upon the "attitudes and sentiments of the group as a whole," rather than in terms of simple cause-and-effect relationships of white factory walls and increased output.

A FIVE-YEAR STUDY OF AN ISOLATED GROUP

The experiment which is analyzed consisted of the isolation of a small group of relay assemblers in a "testroom" for a period of about five years, and the introduction of various changes in the environment with the initial idea of determining the effect of these changes upon the output of the group. In April, 1927, five young women, skilled relay assemblers, were taken from the main shop and put in the testroom. Also in the room were a layout operator, a supervisor, a junior clerk, and, for most of the time an inspector, and one or two other residents. The main group, however, consisted of the five relay assemblers, the layout operator, and the supervisor. Of the five girls, operators "1*a*" and "2*a*" were replaced by operators "1" and "2" at the end of 1927, and operator "5*a*" replaced operator "5" from August 5, 1929, to May 14, 1930.

During June, July, and August of 1932, the regular operators were replaced by novices who stayed until the end of the experiment in February, 1933. In April, 1930, the operators' seating arrangement was changed; they were restored to their original positions in February, 1931.

The work of the operators consisted of assembling some 26 to 52 parts, depending upon the type, into a relay. Each girl worked entirely independently of the others. The girls were seated along one long bench, and the work involved rather close attention. For output records, the various types were reduced to "standard" relays, and the average time for assembling such a relay was about 40 sec. The girls were paid on a group-bonus basis, as they had previously been paid before entering the testroom. However, the group was now small enough to produce a significant pay incentive.

Various records were kept. The most important record was that of output. A completed relay was dropped through a chute rigged with a recording device which punched a tape as the relay slid through. Quality records, in the form of the number of rejected relays and piece parts rejected by the operators, temperature and humidity data, type of relay and frequency of type changes, a record of hours of sleep for each operator, and reports of medical examinations were also available. This information was supplemented by records of the experimentally introduced environment changes; the entire period of the experiment was divided into 21 subperiods each including a particular arrangement of hours, rest pauses, and refreshments. The value of all these data was greatly enhanced by a record of samples of conversation and events which seemed important to those in charge of the experiment. It is by means of this daily log that Professor Whitehead is able to describe the social situation in the testroom.

PHYSICAL FACTORS AFFECTING THE WORKER

The first part of Professor Whitehead's analysis relates to the various physical factors. The effects upon output of (1) the experimental periods (each considered as a unit), (2) hours of rest, (3) periodic illness, (4) cyclical changes, vacations, and holidays, (5) changing types of relays, (6) temperature and humidity, and (7) records concerning quality are examined in turn. The most frequently used output figure is that of weekly output rate for each operator. These weekly output records are refined by the use of moving averages. Four-, twelve-, and fifty-two-week moving averages are put through the data, and from these moving averages output fluctuations which are primarily associated with the time spans 1–4 weeks, 4–12 weeks, and 12–52 weeks have been isolated.

The conclusions from this part of the analysis are summarized by Professor Whitehead (pages 88–91) as follows:

A. The Experimental Periods.

The 23 experimental periods are mainly distinguished by changes in weekly and daily hours of work, in the number of days worked per week, in the number and arrangement of rest pauses, in the supply of light refreshments, and, consequent on these, in the value of the weekly pay cheque.

1. With one exception, no changes in output rate are attributable to these experimental alterations of circumstance. The solitary exception occurs in period 12, where the total abolition of rest pauses seems to be the main cause of a 4% drop in output rate below its trend, but this did not bring the rate into line with other formally comparable periods.

B. Hours of Rest.

Nightly hours of rest were found to depend somewhat on the social habits of the individual workers and showed a definite weekly cycle.

[1] "The Industrial Worker," by T. N. Whitehead, Harvard University Press, Cambridge, Mass., 1938.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

No seasonal cycle was detected. All the workers, over the whole period examined, averaged about the same number of hours' rest per week.

1. With one exception, changes in weekly hours of rest fail to correlate with those in weekly output rates, the exception being that Operator 4 sometimes showed a relatively poor output rate on weeks during which she had little rest. This result is real, but only occurred when some few causes, out of a larger number, were the reasons for the short rest.
2. Daily rates of work fail to correlate with hours of rest on the second night previously.
3. Daily rates of work fail to show a significant correlation with hours of rest on the previous night.
4. Nightly hours of rest fail to correlate with rates of work on the previous day.

C. Periodic Illness.

1. Probably the effect of periodic illness is slightly to decrease working rates for two or three days. This effect, if real, is a minor one.

D. The Annual Cycle.

1. The change of seasons throughout the year has no effect on output rate.

E. The Weekly Cycle.

The effects of the weekly cycle are subject to individual differences; the following is the typical picture:

1. The various midweek days (Tuesday to Friday) all carry substantially equal rates of output.
2. Mondays and Saturdays tend to have rates of output somewhat below those of the midweeks. The differences in rates between the Mondays and the midweeks typically vary from 0 to about 5%. The corresponding figures for Saturdays are 0 to about 2%.

F. The Daily Cycle.

For the first half hour of the day, working rate tends to be something less than 10% below normal. Apart from this, average variations within the daily cycle are well under 5%. These effects are not constant and they vary from one operator to another.

G. Annual Vacations.

1. Output rates during the last two weeks before vacations are slightly below their trend, falling about 2%.
2. The first week after vacations carries a low working rate—about 3% below its trend. Most, but not all, of this occurs during the first day after each vacation when the defect is roughly 10%.
3. There is no significant difference in the average rate of work for 15 weeks before a vacation as compared with that for 15 weeks after.

H. National, State, and Casual Holidays.

1. A single day away from work, taken for whatever reason, tends to result in a rate of work on the day after about equal to that of the preceding and following Monday; i.e., 0 to 5% below trend.
2. The day before a holiday is not accompanied by an abnormal output rate except in the case of Christmas, where output is apt to be slightly depressed all through the previous week.

I. Changing Types of Relays.

1. Long-time variations in the number of relay types assembled *may* have some effect on output rate by affecting the character of the useful work patterns. If this is so, the effect is small. This must not be confused with the undoubted fact that type changes encourage a certain flexibility of work pattern. What is referred to above is the possibility that, granting type changes, output rate might be affected by a moderate difference in the frequency of these changes.
2. The weekly rates of type changes and output fail to correlate in the case of the experts. The novices could not be checked for this for technical reasons.
3. The experts worked as fast during the first hour after changing relay type as on the subsequent day. In the case of the novices, the rate of work for the first hour was roughly 5% below that of the subsequent day.

J. External Temperature and Relative Humidity.

1. Slow seasonal changes of temperature and of relative humidity had no effect on output rate.
2. Exceptional spells of hot weather had only a minor adverse effect on weekly output rate, even in the case of Operator 5, who was brought up in Norway.

Exceptional spells of cold weather show a minor adverse effect on weekly output rate.

Weekly output rate was little affected by the simultaneous occurrence of exceptional temperatures and relative humidities.

3. During both summer and winter, variations in the average daily temperature and relative humidity have no influence on daily output rate, either when considered separately or in combination.

K. Room Temperature and Relative Humidity.

1. Slow seasonal changes of temperature and of relative humidity had no effect on output rate.
2. Weekly changes in these two factors, both in summer and in winter, failed to affect weekly output rates, whether considered separately or in combination.
3. Daily changes of temperature and of relative humidity had no effect on daily output rate, whether considered separately or in combination.
4. Variations in the daily *range* of temperature and of relative humidity fail to affect daily output rate.

L. Records Relating to Quality.

1. Variations in the suitability of piece parts fail to correlate with variation in output rate.
2. Variations in the suitability of piece parts do occasionally affect the number of defective relays assembled. This number is always too small greatly to affect output rate.
3. Except as stated above, variations in the number of rejected relays fail to correlate with the physical factors already considered.

To appreciate these conclusions from the foregoing brief statement of "the facts" is difficult, for each conclusion is the result of a very painstaking analysis elucidated by many excellent charts. That "daily rates of work fail to show a significant correlation with hours of rest on the previous night" can be more easily appreciated, for example, after viewing the scatter diagrams for each operator which show the considerable variation in both daily output and previous hours of sleep and the lack of any significant correlation between the variables. The particular conclusions are made more interesting because the operators, in many instances, were themselves convinced that these physical factors were quite important in influencing output rate.

VARIATIONS IN PHYSICAL ENVIRONMENT HAVE LITTLE INFLUENCE UPON RATE OF WORK

Interesting as the particular conclusions are in themselves, their importance is increased by viewing them as an entity. From this point of view they constitute a formidable mass of evidence tending to show the relative insignificance of variations in the physical environment, at least in this particular experiment, as an influence upon rate of work. Caution is necessary, however, in interpreting this statement. In the first place, Professor Whitehead points out that variations in the physical environment were not pushed beyond what he terms the indifference range. For example, if an operator had had no sleep for say four nights it is inconceivable that output rate could have been maintained. Or, to quote a footnote (page 242): "In the early days of the World War (1914), the rear guard of the British Army retreated, fighting daily, for about 10 days, and marched about 200 miles in this time. Although most of these men had never experienced a war until a few days previously, it was not always easy to prevent them from falling asleep during the actual fighting. This is an extreme instance of what occurs when one factor passes well out-

side its 'indifference range.'" Nevertheless, the experiment does suggest that the various indifference ranges for the factors involved are wider than one would expect to find.

In the second place, it must be remembered that the various physical factors are indirectly influencing the attitude of the various operators toward the experiment. To separate the physical environment from the social and psychological reaction to that environment is not easy, though it be real and important. For example, consider the matter of rest pauses. While the experimental periods, which contained various arrangements of rest pauses as one variable, do not show, on the whole, a significant correlation with output fluctuations, the favorable reaction on the part of the operators to rest pauses unquestionably was one influence which led them to look with favor upon their new environment. However, rest pauses were only one of a number of factors which induced this generally favorable reaction on the part of the workers, and it is impossible to say just how much importance should be attributed to any one of the various physical and social situations. The mutually interdependent action of the variables cannot be neglected.

SOCIAL SITUATION IN THE TESTROOM

The second part of Professor Whitehead's work, which deals with the social situation in the testroom, is difficult to summarize in terms of a few factual conclusions. For one thing, this phase of the work is, in part, a description of the social activity in the testroom. Such a description gives the reader an appreciation of the personalities of the individuals and of their reactions toward particular incidents, such as changing the seating arrangement, and toward the experiment as a whole.

This descriptive background, taken as a whole, supports the conclusion that the operators are reacting to the social situation as they see it, and that their over-all attitude toward the experiment is the dominant factor in shaping their respective responses. This is particularly true of the general upward slope of the output curves which lasted during the major portion of the five-year period. Though these girls were skilled workers upon entering the test room they immediately started to increase their working rates. They looked upon the experiment as something designed to improve working conditions for themselves and for others. They acquired prestige in the eyes of other workers and the management, and in their homes. Furthermore, they liked the new environment. Rest pauses were pleasant; the relaxed supervision was appreciated; and the attention of high company officials gave them encouragement. All these things made the workers desirous of cooperating. This was particularly true of one operator, who became the leader of the group. This leader was also influenced, probably more than the others, by the opportunity for increased earnings which became possible with the small group as the basis for the bonus system. This leader gradually won over a second operator, with whom there had initially been some conflict, and the two together brought into being a teamwork which effectively reached higher and higher output levels.

This favorable situation was modified in the later stages of the experiment. When a new operator was brought into the group (operator 5*a*) the possibility of breaking group records was destroyed. At about the same time management gradually lost interest, to a certain extent, in this particular experiment. The expectation that significant scientific results would be discovered by the experiment was also dimming. Their work became more and more just a job, and less and less cooperation with management in the interest of science. The coming of the depression furthered this reorientation of attitude. With this change of attitude work rates ceased to rise and in some cases fell off.

PRODUCTION FLUCTUATIONS AS RELATED TO TIME SPANS

In addition to pointing out the general conformity of production rates and the general attitude of the workers, Professor Whitehead analyzes production fluctuations much more closely by studying the correlation among the operators in their output fluctuations in the various time spans (1 day–1 week, 1–4 weeks, 4–12 weeks). The short fluctuations, principally the variations of daily output from average for the week, correlate highly among friends. These friendship relationships are found most commonly among pairs seated next to one another; however, one friendship pair is isolated by one operator. Thus the very short fluctuations in output seem to be more an individual than a general social phenomenon. Nevertheless, it is extremely interesting that there should be this sympathetic fluctuation in output.

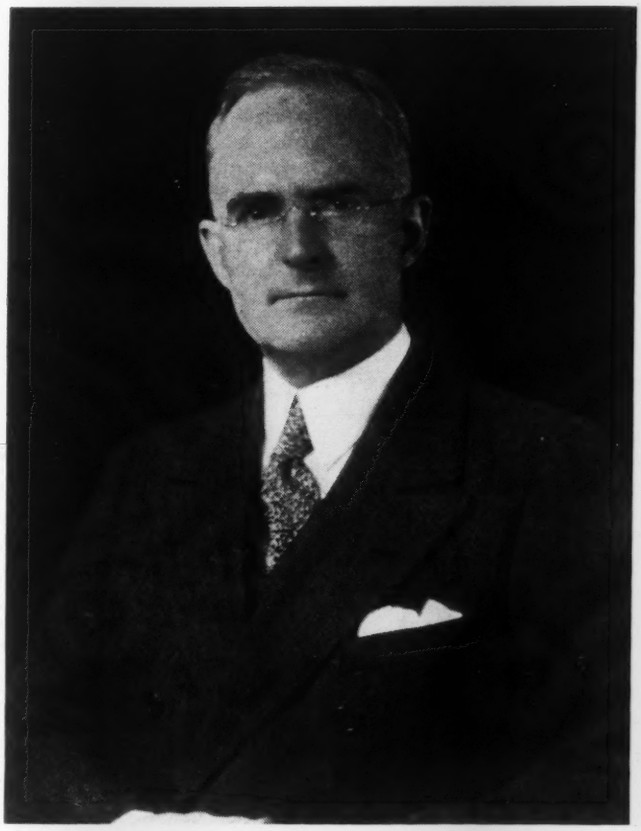
As one proceeds from the short fluctuations to the fluctuations in the longer time spans, the "teamwork" as indicated by the correlation coefficients becomes more and more a general social phenomenon, depending more upon the general attitude of the group. Among the longer time-span fluctuations, the 1–4 week relationships are more easily disturbed than the 4–12 week relationships. For example, the 1–4 week relationships were broken down by a change in seating arrangements while the 4–12 week relationships were strengthened. This would appear to indicate that the longer fluctuations depend to a greater extent upon the general social situation which is more stable than those relationships which are, figuratively speaking, closer to the individual.

One of the most interesting features of the statistical study is the way it supports the thesis that changes in attitude become effective during a short period of time, usually over a holiday or vacation. This does not mean that the causes appear suddenly and immediately become effective, but that more and more incidents occur which are incompatible with the existing attitude until finally the old attitude gives way suddenly to the new attitude. A holiday or vacation, during which working attitudes are more in the background, seemed to provide a logical time for a change of attitude to make itself felt.

FIVE-YEAR PERIOD ENHANCES STATISTICAL VALIDITY OF STUDY

The conclusions from this experiment are especially interesting because the observations took place over a period of five years. This not only adds to the statistical validity of many of the correlations, but also gives greater assurance that temporary and impermanent influences will not be mistaken for more fundamental forces. While it has not been possible to give a well-rounded picture of the entire analysis, the essential conclusions of the study are clear. The principal conclusion is the importance of human relationships in the determination of the output rates of this small group of workers.

This conclusion is supported, in the first place, by the negative findings of the relation of physical environment changes to output; in the second place, by the positive relation of output fluctuations to changes in human relations. From the sympathetic day-to-day output fluctuations of friendship pairs to the similar trends over the five years, one sees the operation of a social organization, motivated primarily by the reactions of the individuals to their entire environment, and the outstanding aspect of that environment was the human relationships which were built up within it.



J. P. H. PERRY, CHAIRMAN, E.C.P.D.

E.C.P.D. TAKES STOCK *and* PLANS *for the* FUTURE

AS THE Engineers' Council for Professional Development enters the sixth year of its existence, it finds its prestige securely established by the record of specific achievements; it faces a program of continuing effort applied to problems that involve most of the original objectives; and it looks forward to future activities of inestimable benefit to the engineering profession with enthusiasm and confidence based on the growing support of engineering practitioners, educators, and examiners. An organization constructively critical of engineering education, of professional training and recognition, and of the individual from the time he prepares to select engineering as a course of study to the time he is competent to be recognized by law and by engineering societies as having attained professional status, E.C.P.D. has applied to itself its techniques of analysis and forward-looking program formulation in a manner which demonstrates its sincerity of purpose and its virility. Its apparent weakness, which arises from the fact that it is a small group of volunteer enthusiasts who meet infrequently, whose work is relatively little known and understood, whose function is almost entirely exploratory, and whose relationship with other organizations is principally advisory, may, paradoxically, be the source of its strength. Limited but representative membership avoids some of the confusion that results from popular participation in any program affecting an entire profession, infrequent gatherings make necessary the reiteration of purposes and procedures and provide the time essential for the maturing of well-considered action, while comparative freedom from administrative friction and power to enforce its recommendations eliminates suspicion that the E.C.P.D. seeks to usurp the authority of other bodies.

Of the validity of the foregoing statements, the 1938 annual meeting of the E.C.P.D. in New York, on October 21 and 22, gave ample evidence. The program of the meeting may be divided into three parts: routine business, including the election of officers and chairmen of committees; presentation and discussion of the reports of the chairman, C. F. Scott, and of the four major committees; and a dinner session at which informal addresses gave members of the Council plenty to think about.

J. P. H. PERRY ASSUMES CHAIRMANSHIP

Most significant of the elections announced were the selection of J. P. H. Perry, vice-president, Turner Construction Company, as chairman of the Council and the naming of R. E.

Doherty, president of Carnegie Institute of Technology, vice-chairman. C. F. Scott was elected chairman of the Committee on Professional Recognition and S. L. Tyler, secretary of the American Institute of Chemical Engineers, becomes the new secretary. C. E. Davies, secretary, A.S.M.E., remains as assistant secretary.

Mr. Perry, a civil engineer of New York, is known as a forceful and practical engineer and man of affairs. He has been a representative of the American Society of Civil Engineers on the Council since 1934 and is typical of the practitioner as contrasted with the educator in point of view. His forthright both-feet-on-the-ground attitude should go a long way in attracting practicing engineers, many of whom have been somewhat mystified by the broad and idealistic program of E.C.P.D., to a worthy cause that needs their support.

Professor Scott has the background, the time, the enthusiasm, and the vision to direct the work of the Committee on Professional Recognition, concerning which the most serious differences of opinion within the Council have developed so far, and which, in the final analysis, is of the most immediate bread-and-butter concern to engineers above the college level. As president of the National Council of State Boards of Engineering Examiners, and chairman of the Board of Engineering Examiners of the State of Connecticut, he is in constant contact with the practical phases of licensing, and from long personal experience with engineering practice and engineering society affairs, he is equipped to judge the standards by which engineers estimate the qualifications of those who seek professional status through society membership.

The other committees retain chairmen who provide superior leadership. Dean Sackett, who heads the Committee on Student Selection and Guidance, is in a position to devote a major portion of his time to a problem that has long engaged his interest. O. W. Eshbach, of the Committee on Engineering Training, was closely associated with the late Gen. R. I. Rees, and, because of his personnel activities with the American Telephone and Telegraph Company, is in daily contact with young engineering graduates and their problems. As chairman of the Committee on Engineering Schools, Karl T. Compton, president of the Massachusetts Institute of Technology, possesses the first-hand knowledge of the conditions, trends, and functions of engineering education essential to the work of that committee.

C. F. SCOTT ACCLAIMS E.C.P.D. AS A CONTINUING PERMANENT AGENCY

In the chairman's contribution to the sixth annual report of E.C.P.D., Charles F. Scott announced as his keynote, "E.C.P.D. as a continuing permanent agency." He reviewed what he termed the "pioneering" period and defined E.C.P.D. as being "both exploratory and promotional." "It proposes measures," he explained, "and on approval administers them primarily through the cooperative support of the constituent organizations." He then briefly reviewed and appraised the results attained through the activities of the four major committees. "Our conspicuous achievement," he pointed out, had been the accrediting of engineering curricula in the schools. Selection and guidance had been investigated and progress had been made, but "richer returns in insuring engineering quality at the source" demanded "more than the voluntary efforts of one man, even one as devoted and effective as Dean Sackett," could supply. "Big things must be handled in a big way."

In answer to the query "After graduation—what?" Professor Scott outlined the work of the Committee on Professional Training and the challenge it presented. "It merits an organization and support on a comprehensive scale," he asserted, "with funds for travel and for investigation and for publication."

In referring to professional recognition as a goal, Professor Scott said that "this difficult and involved problem is not to be settled quickly." As to results in general, some had been conspicuous, like accreditation, while others, like guidance, were intangible—"not conspicuous and definite and exciting." The next step lay in a changing world where "engineering must change, and our projects open a vision showing ways in which engineering can be made continuously better." He closed his report with a summary of the year's activities, and a résumé of his own relationship to the changing conditions surrounding engineering education and training.

R. L. SACKETT ANNOUNCES REVISION OF GUIDANCE BOOKLET

The report of the Committee on Student Selection and Guidance provoked much discussion. Dean Sackett outlined the problem with which the committee was concerned, which has to do with men who are dropped from engineering schools because of scholarship or who withdraw because they find themselves unfitted to continue their engineering studies. The number of such men is as high as 40 per cent of the total number of men entering engineering courses. The problem, said Dean Sackett, was being attacked on one front by providing information to counselors of youth, and to this end 18,000 copies of The Engineering Foundations' booklet, "Engineering—a Career, a Culture," supplied to E.C.P.D. by the Foundation, free of charge, had been distributed.

Considerable discussion arose as to the value of the booklet, in light of the fact that Dean Sackett announced that a revision was in progress and funds for its publication were urgently needed. It appeared to be the consensus of opinion of those who had distributed the booklet that it was positively helpful to parents and adult counselors, but that it was not so effective as guidance material for the boys of high-school age who were contemplating a course in an engineering school.

Other ways in which the guidance problem was being attacked were noted, such as the aid to the work given by professional engineers in their own communities and guidance tests, which, the chairman said, were still in a pioneer stage.

Considerable discussion revolved around the objectives and value of guidance. Dean Sackett vigorously defended the underlying purpose of his committee's work. Boys, he said, were easily misled in choosing an educational program, and not only did the boys suffer as a result, but society suffered as well. It was his opinion that young men should not be led to aspire to goals they could not attain, as such a procedure led to defeatism, and a tragedy might be involved.

Taking a less serious view of the tragedy that might result from a boy's not continuing into an engineering career, A. R. Stevenson, Jr., member A.S.M.E., of the General Electric Company, suggested that the drift from the engineering career might be a success, in an individual case, and not a failure. An engineering training, he contended, was better than the old-fashioned academic training. It was to be remembered that mind training was the important thing, and this an engineering education provided. While we did not want inferior men to hold back brighter men, it was an advantage, he said, to have an excess of men trained in engineering colleges. The college itself, he pointed out, made a selection of men who could be successful. Citing the experience of the General Electric Company with engineering-college graduates, he said that about half became sales engineers, and that the best flowed out of strictly engineering work into executive positions.

Harry S. Rogers, president Polytechnic Institute of Brooklyn, suggested that a school for guidance counsellors might be

set up with the object of acquainting those in contact with young men with what E.C.P.D. was trying to accomplish.

Coming specifically to the question of the revised edition of "Engineering—a Career, a Culture," the Council authorized the Committee on Student Selection and Guidance to spend a sum not to exceed $200 for revising and editing a text to be submitted to the Council for approval.

O. W. ESHBACH PROPOSES A BROAD PROGRAM

For the Committee on Professional Training, Ovid W. Eshbach, chairman, announced that the report of the committee proposed a study of local society activities and interests in cooperation with the several societies and with the purpose of clarifying future policies or steps to be taken. In a review of the activities of the year 1937–1938 he noted the distribution and sale of publications with the cooperation of the E.C.P.D. headquarters office. These publications included nearly 2000 copies of "Suggestions to Juniors" and the "General Reading List;" approximately 1000 copies of "Selected Bibliography of Engineering Subjects;" and about the same number of "University Extension Facilities." In addition, numerous reprints of helpful articles, "After Graduation" and "The Engineer of Today and Tomorrow," were distributed. In connection with The Pennsylvania State College, the Committee contributed a program of three papers and a discussion leader for the Annual Industrial Conference.

Following a résumé of important elements and opportunities in professional development, the report recommended that before the committee "undertakes any further major activities, a joint study be made, through the educational committees and section chairmen of the several societies. This investigation should ascertain: (1) the nature of present activities, (2) the facilities available for them, (3) the manner in which they are sponsored and promoted, and (4) the response to them. The report should attempt to crystallize opinion as to: (1) further policy, (2) fields of activity of the several educational committees, (3) means of coordination with local educational institutions and if necessary, between societies, and (4) more effective ways of increasing membership." The Council voted to endorse this recommendation.

Mr. Eshbach also mentioned a number of other studies that the committee might undertake, such as graduate study, opportunities for engineers, culture, cooperative education, and self-education, and inquired if the subjects were, in the opinion of the Council, within the scope of the committee. Upon motion it was voted that these subjects were within the committees' scope.

J. W. BARKER REPORTS ON A STUDY OF PROFESSIONAL RECOGNITION PROCEDURE

A progress report of the Committee on Professional Recognition was presented by J. W. Barker. It consisted of two parts: One was devoted to the revision of the "Model Law for the Registration of Professional Engineers and Land Surveyors," and the other concerned an exhaustive study of methods of recognition employed in the other professions.

Dean Barker explained that the committee was concerned with uniformity in engineers' registration laws and not with the philosophy of registration, and that he was reporting on what had been accomplished in the revision of the Model Law for the information of the Council.

A report on methods of professional recognition in use in such professions as accounting, architecture, law, and medicine was submitted in summary form and without comment. The main report, a document of considerable bulk, Dean Barker said, was being duplicated so that the committee could study it.

K. T. COMPTON SUMMARIZES RESULTS OF ACCREDITATION

Gratifying results and impressive statistics on the scope of the work involved in the task of accrediting curricula in engineering schools were presented by Karl T. Compton, chairman, in the report of the Committee on Engineering Schools. Dr. Compton stated the general objective of the committee, "to formulate criteria for colleges of engineering which will insure to their graduates a sound educational background for practicing the engineering profession," described the procedure of accreditation and the policy upon which the committee's work was based, and pointed out that the direct benefits incidental to the program included the advisory service which had been made available to institutions, a study which the committee was currently making of the admission of students with advanced standing upon transfer to accredited curricula from nonaccredited curricula, and activity toward assuring a comprehensive survey of the status and trends of engineering education.

In commenting on the status of the accrediting program, the report stated that it had been successfully established at the beginning of the year 1937–1938. At the end of 1936–1937, as reported a year ago, 626 curricula at 129 institutions had been inspected and final action had been taken on 617 curricula. For the period covered by the present report, the committee was prepared to submit recommendations on 62 additional curricula involving 6 institutions that had submitted curricula for the first time. Twenty-two curricula previously accorded "term" accrediting and seven curricula initially voted nonaccredited were among those reinspected.

The committee, according to the report, had focused attention on plans for assuring the continuation of the accrediting program. The financing of this continuation program had not yet been worked out, although tentative plans, involving annual fees of about $3500, to be contributed by the institutions on the list, and an equal amount necessary for overhead expense, had been discussed.

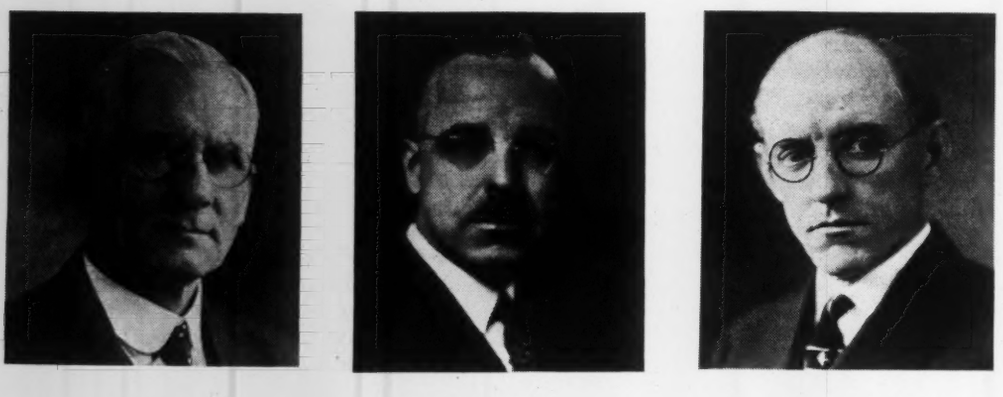
The report also included a discussion of some problems involved in accrediting, such as specialized curricula, evening and cooperative curricula, curricula in chemical engineering, and standards of accrediting.

INFORMAL DINNER TALKS POINT WAY TO FUTURE PROGRAMS—W. E. WICKENDEN INTRODUCES "PATTERNS OF COMPETENCE"

Under the relaxing influences of a good dinner and good fellowship, Professor Scott stimulated a series of brief informal discussions at the Engineers' Club on Friday evening. Starting the ball rolling by quoting some suggestive passages from his own report, already noted, he called upon W. E. Wickenden, president, Case School of Applied Science and member A.S.M.E., who enumerated the goals already attained by E.C.P.D. and suggested a formulation of "patterns of competence" to guide engineering schools as a field for further effort.

The seven goals which E.C.P.D. had attained were listed by President Wickenden as follows:

(1) Made principle of joint action by profession effective in a new major area
(2) Won recognition of engineering education, including precollege and postcollege stages, as an organic whole and a major concern of the profession
(3) De facto acceptance of professional licensure by entire profession and implementing with nationally accepted educational credit
(4) Accreditation of colleges, for guidance of public and validation of credentials
(5) Resurvey of engineering colleges from accrediting data
(6) Contributions to student guidance and selection



C. F. SCOTT S. L. TYLER R. E. DOHERTY

(C. F. Scott retires as chairman of the E.C.P.D. and becomes chairman of the Committee on Professional Recognition; S. L. Tyler is the new secretary of the E.C.P.D.; R. E. Doherty is the new vice-chairman.)

(7) Contributions to extension of eduation at the adult level.

In presenting his suggested "field for further effort," President Wickenden said that he questioned the validity of job analysis technique in its details, although he recognized it in broader outlines. Personal competence, as an end sought in education, he said, could be broken down into fairly objective elements, as, for example, express attainment to be sought at graduation in the following:

Competence in graphical presentation
Competence in chemical laws, data, and technique
Competence in physical laws, data, and technique
Competence in mathematical analysis and computation
Competence in written and spoken English
Competence in social understanding
Competence in interpreting financial data
Competence in solving problems of engineering economy
Competence in meeting ethical and personal problems
Plus variants distinctive for civil, mechanical, electrical, mining, metallurgical, chemical engineers, etc.

Faculties, he said, were prone to think exclusively in sequences of subject matter and laboratory exercises, and needed the corrective of a type of product to be turned out, expressed in terms which they could relate to educational procedures without too great a strain on the imagination. This suggestion, which involved a different axis of reference than the usual curricular axis, to balance but not to displace the latter, was suitable for a joint effort of practitioners and educators. It might help to reconcile the contradictory voices of many industrialists and alumni on one hand, he pointed out, and the strict constructionists of the profession on the other. The former group, he said, often suggested that only a few engineers be trained to continue as such, and hence urged that the amount of time devoted to the study of basic science be reduced, a good deal of technology thrown out, and business orientation substituted for them. The latter group, on the other hand, urged that narrower entrance restrictions be instituted, that enrollment be reduced, that a longer course be adopted, and that a more profound scientific grounding be provided.

E.C.P.D. could help make it clear, he concluded, that colleges could not produce for quickly shifting demands. With a four-year production cycle and a limited selection of material, colleges could not easily "retool" their plants and revamp their personnel. It therefore resulted that the best service the colleges could render would be to equip men for long-sustained personal and professional development after graduation. Enlightened industries and engineers recognized this fact, he asserted, but the problem remained of gaining a wider acceptance of it.

K. T. COMPTON PROPOSES "RESEARCH FELLOWSHIPS"

A million man-miles without a fatal accident was the record claimed for the Committee on Engineering Schools by its chairman, Karl T. Compton, in a statistical résumé of the accrediting program. Reviewing the benefits that have already been noted from the program, already set forth in the digest of the report just presented, Dr. Compton reiterated his contention that a continuation of the work of his committee was a matter of dollars and cents. The annual expense of $7000 which he estimated as necessary for this work should, in his opinion, be contributed jointly and in equal portions by the schools themselves, to cover the actual costs of visits to the institutions by the "delegatory committees," and by the engineering profession, to cover the overhead.

Coming to the subject of graduate instruction, touched on in the committee's report, Dr. Compton referred to the Rockefeller program of national research fellowships, now tapering off, that were available to doctors of philosophy and that had given to promising young men (his brother, Arthur H. Compton, had been one), in the best years of their lives, opportunities for study and research. This research-fellowship program, he said, had been conspicuously successful and had made scientific work in the United States of a first-rate order.

Nothing like these research fellowships had ever been attempted in engineering, he pointed out. In fact, he said, the value of research and of graduate schools in engineering had been questioned as late as 1920. He proposed, therefore, a long-range program for meeting the opportunity of doing for engineering what the national research fellowships had done for science. In 10 or 15 years, he contended, the results of such a program would be evident in the quality of teaching in engineering schools. He had talked, he said, with two men who had interests in large estates, and he was hopeful that the problem of financing might be solved. Such a program as he was suggesting, he concluded, should be under the jurisdiction of a group of distinguished engineers, perhaps the Committee on Engineering Schools of E.C.P.D.

J. B. CHALLIES PROTESTS HE IS "NOT A FOREIGNER"

In introducing J. B. Challies, president of the Engineering Institute of Canada, who, with J. M. R. Fairbairn, past-president, and H. W. McKiel, incoming president of the Institute, and L. A. Wright, its secretary, were guests at the dinner, Professor Scott was incautious enough to refer to him as a "for-

eigner." Mr. Challies' witty address took full advantage of this lapsus linguae and was eloquent in his assertion that every strategic point of the international boundary between the United States and Canada was marked by engineering works that joined the two countries together. E.C.P.D., he said, was not only "exploratory and promotional," as Professor Scott had remarked so many times, but inspirational as well.

C. E. DAVIES GIVES A "CHALK TALK"

In an attempt to simplify the aims and objectives of E.C.P.D., C. E. Davies, first secretary of the Council and one of those who had taken part in the events that led to its formation, drew a diagram on the blackboard on which he plotted the growth curve of a hypothetical engineer from primary school days to the time of his recognition as a full-grown professional engineer. By dividing the curve into sections representing pre-college, college, subprofessional, and professional sections, he pointed out the areas of influence in which the four major committees of the Council were concerned. He called particular attention to a probable dip in the curve immediately following graduation, which, he said, was the distressing factor that had first attracted the attention of the group that eventually organized, with the aid of others, the Engineers' Council for Professional Development.

R. E. DOHERTY POINTS TO A NEED FOR A PHILOSOPHY

In introducing R. E. Doherty, newly elected vice-chairman of E.C.P.D., Professor Scott called attention to his educational work with young graduates in the training courses of the General Electric Company, to his attempts to introduce new educational techniques as professor of electrical engineering at Yale, and subsequently as first dean of the Yale School of Engineering, and to his present services to engineering as president of the Carnegie Institute of Technology, which have included ability to secure a large endowment for that institution. President Doherty prepared, at the request of Professor Scott, the following résumé of his remarks.

"There is an opportunity, and I think responsibility, to which the E.C.P.D. should direct its attention. I wish to repeat and endorse a statement made some years ago by President Wickenden, which was in substance that a philosophy of engineering education—indeed of engineering itself—had not yet been framed. There are generally accepted broad definitions of engineering—statements of individual opinion as to the what and why of engineering—and a varied and changing pattern of engineering practice that is clear, clean cut, and well articulated in central areas but frayed out badly at the edges. But nowhere is there an authoritative statement of professional faith and purpose which might give intelligent direction to the now confused but earnest efforts of those who would help on-coming engineering generations get ready for their responsibilities. Faculties alone can't provide such a statement. An engineering society can't do it. Neither can a state board. It is a job for concerted thought and collaboration—a job for precisely this joint body representing them all.

"And I urge it be undertaken. It would require time, probably months and perhaps years, and much effort and debate. But the results would be worth the cost. Educational administrators and faculties that are now hounded on the one side by demands for greater technical specialization and on the other for less, could then emerge from a justifiable timidity and deal with the situation with courage and confidence, because they would have the backing of E.C.P.D. on *principle*. There must not be authoritative curricula; institutions must be free to plan their programs. But in doing so they must have guiding principles that bear the endorsement of the profession as a whole. And until the profession as a whole, as represented by the E.C.P.D., establishes such principles, it is, if I may speak frankly, guilty of a fundamental omission and thus is responsible for delaying vital progress."

H. S. ROGERS PLOTS COURSE FOR E.C.P.D. THINKING

Called upon to express his views, H. S. Rogers, president Polytechnic Institute of Brooklyn, extemporaneously plotted a course for E.C.P.D. thinking on which he integrated many of the remarks of previous speakers. At the request of Professor Scott, he prepared the following résumé of his remarks:

"As I have been sitting here this evening listening to the remarks of others, there are two thoughts which have been running through my mind and which, in a manner, correlate and give perspective to all the other comments. One has to do with a concept of the individual engineer's training and achievements, and the other, with the purpose of the E.C.P.D.

"The former unites the abstruse discussion of President Wickenden upon patterns of competency with the plane geometry of Colonel Davies upon graphs of individual progress in a spacial concept of three dimensions involving areas (that's a good Columbia term) of knowledge and levels of competency. Such a spacial concept may provide a base where the breadth of scientific, humanistic, or artistic knowledge possessed by the individual may be visioned and where the level of his achievement in critical understanding or in competent use maybe approximated to give, upon the surface, a contour of culture.

"The primary purpose of E.C.P.D. is directed toward the development of the engineer in his cultural breadth and his level of understanding and competency. In the achievement of this purpose the Council might find an analogous philosophy in John Dewey's "pupil-centered school." The entire program of E.C.P.D. should be focused upon the development and recognition of the individual. Dean Sackett's Committee on Student Selection and Guidance is promoting and aiding service to those individuals who give promise of capacity for achievement in the field of engineering education. Mr. Eshbach's Committee on Professional Training advocates aid to individuals at the junior level of engineering responsibility by national societies, by local groups, and by engineering leaders. The program of accrediting engineering schools has been and should be motivated not by the purpose of controlling the schools but by the purpose of certifying to the minimum essentials available to the individual who seeks an engineering training. The work of the Committee on Professional Recognition has been directed toward the establishment of certain criteria and goals so that younger engineers may focus their objectives and appraise their progress. While the program of licensure is related to professional recognition, its purpose should be confined to the protection of the public by the establishment of minimum standards of competency. E.C.P.D., on the other hand, is concerned with the progress of the individual toward competency and his development upon the higher levels.

"The remarks of President Doherty upon the part which E.C.P.D. could play in formulating a philosophy of engineering education suggest the development of a more vital and more vigorous program of engineering education through a better understanding of the engineering thought process and of the engineering function in society, and the more effective development of individuals through engineering discipline. The remarks of President Compton suggesting the possibility of stimulating engineers through the establishment of fellowships as others have been stimulated in science suggest the need and desirability of supporting and developing individuals of promise. Just as the program in secondary education today is focused upon the development of students rather than upon

the teaching of subjects, so E.C.P.D. should focus its attention and interest upon the development of the student in the school and the attainment of competency by the young engineer after graduation. E.C.P.D. should think not in terms of prescribing curricula but in terms of stimulating and aiding engineering education; it should think not in terms of controlling the profession by licensure but in terms of the development and recognition of that competency necessary to protect the public welfare and worthy to receive recognition by membership in the engineering societies."

D. S. KIMBALL HAS A GOOD WORD FOR LATIN

Declining at first to be heard, on the preposterous grounds that he was somewhat old fashioned, Dexter S. Kimball, dean-emeritus of engineering, Cornell University, and past-president A.S.M.E., spoke from the wealth of his wisdom and experience. He had gone to Cornell, he said, under Henry R. Thuston, first president of A.S.M.E., who had invented the mechanical laboratory as a preparation for engineering—a preparation that served very well. At the present time, however, the engineer occupied a different place in society and could not be taught in the old way. It was necessary, he said, to prepare the engineer for management, for the engineer would have charge of industry.

As to preparation, Dean Kimball declared himself to be a heretic—he approved of "Latin and the old disciplines." He said that men who had presented four years of mathematics, two of German or French, and three or four of Latin had never failed in engineering courses. The reason for this was, in his opinion, the fact that they had been trained to think, and the modern method did not train men to think.

As a trend of the times he noted the remarkable growth in the number of junior colleges. Instruction in these schools, he pointed out, paralleled that of the first two years in the university. It was there, he said, that selection of engineering students might be made in the future.

In closing he reminded his hearers that influences that lie outside the classroom may have a greater effect on engineering students than influences within the classroom.

F. B. JEWETT HOPES E.C.P.D. WILL BE A PERMANENT BODY

As guest of honor Frank B. Jewett, president Bell Laboratories, had been persuaded to attend the dinner on condition that he would not have to prepare an address. He graciously accepted Professor Scott's invitation to speak extemporaneously however. By coincidence, on the floor of the Engineers' Club below the one on which the dinner was held, the John Fritz Medal Board of Award was in session during the evening, and, quite unknown to Mr. Jewett, was engaged in voting him the John Fritz Medalist for 1939.

Mr. Jewett expressed the hope that E.C.P.D. would continue as a permanent body because, in his opinion, it would have an influence in problems that would confront the engineering profession in the future. He had been trying to look ahead to see what was in store for engineers and the profession against the background of 40 years' experience with the sciences fundamental to engineering. He had noted the ebb and flow of changing conditions and attitudes of schools toward students and curricula, of students to the engineering profession, and of the engineering profession to society. Looking into the future with its vast mass of new knowledge and into changing social conditions, he was of the opinion that it would be quite necessary and desirable, if engineers were to proceed in an orderly manner through the E.C.P.D., to keep the mélange of relationships under the scrutiny of a body of men so eminent in their own right that their findings would be persuasive.

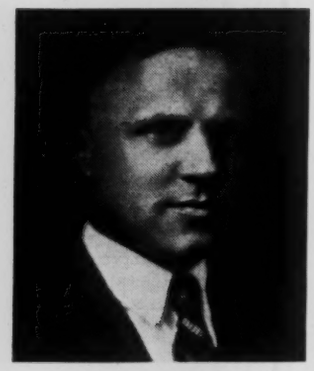
E.C.P.D., made up of eminent men, should continue, he said, and if it did it would have two tasks set for it; first, the task of recruiting a membership of men of eminence, and, second, of resisting all temptations and attempts to acquire power to enforce its findings, and he quoted Elihu Root's opinion on the influence exercised by a body of men of eminence who have no legal power to enforce their recommendations.

P. H. DAGGETT HONORED BY N.C.S.B.E.E.

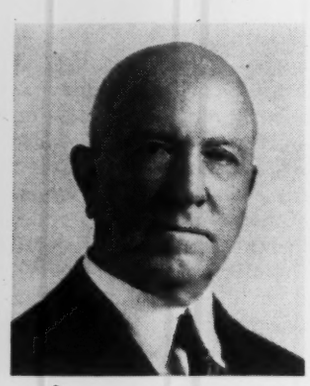
An unexpected and pleasant interlude in the informal after-dinner speeches was afforded by T. Keith Legaré, secretary of the National Council of State Boards of Engineering Examiners, who presented to Parker H. Daggett, dean of engineering of Rutgers University, a "distinguished service certificate" for his services in the advancement of the engineering profession. Mr. Legaré explained that the certificate had been awarded at the recent meeting, in Des Moines, Iowa, of the N.C.S.B.E.E., but that presentation had been delayed because Dean Daggett had been unable to be present at that meeting.

J. P. H. PERRY PLEDGES HIS BEST EFFORT

Bringing a long but fruitful session to a close, Professor Scott reemphasized his vision of E.C.P.D. as a permanent institution. He called upon his successor, J. P. H. Perry, newly elected chairman of E.C.P.D., who humorously noted that he found himself in a group composed of "90 per cent educators and very few practical engineers." He had listened to much talk during the day, he said, but no one had defined "what kind of an engineer or man we want to produce as a result of education." He pledged himself "to try to make all our dreams come true."

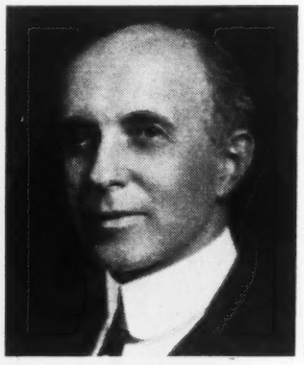


K. T. COMPTON



R. L. SACKETT

O. W. ESHBACH



F. B. JEWETT

(K. T. Compton becomes chairman of the Committee on Engineering Schools; R. L. Sackett, chairman of the Committee on Student Selection and Guidance; O. W. Eshbach, chairman of the Committee on Professional Training; F. B. Jewett was guest of honor.)

A.S.M.E. HONORS AND AWARDS

III—The Junior and Student Awards Established by Henry Hess

HENRY HESS, founder of the heavy ball-bearing industry in the United States and vice-president of The American Society of Mechanical Engineers from 1914 to 1916, after reading a copy of a letter by Calvin W. Rice, dated Jan. 12, 1914, and addressed to James Hartness, president of the Society at that time, was so impressed by Mr. Rice's observations about the need of prizes for technical papers in order to develop the Society, that he immediately wrote a letter to Mr. Rice in which he said:

"The suggestion to offer a prize for the best paper by an undergraduate has particularly appealed to me, and in order to put this into concrete shape, I now make an offer to the Society of $1000, the income from which is to be used for a prize to be awarded each year for the best technical paper by a student member. . . . It is also my opinion that a similar prize should be offered for the best technical paper by a junior member of the Society and, if that meets with the views of Council, I am pleased to duplicate my previous offer (of $1000)." Subsequently, the Council accepted the two amounts of $1000 each.

By conferring this great favor upon the Society and its younger members, Mr. Hess initiated the first of the funds for medals and awards which have been established since then through the generosity of other members.

After discussing with Mr. Hess the details of the competition for the prizes, the Committee on Meetings evolved the rules for the Junior Award and the Committee on Student Branches drew up those for the Student Award. The Junior Award, initially conferred in 1915, was the first award under its sole jurisdiction ever given by the Society. It was closely followed, in time, by the presentation of the first Student Awards in 1916.

JUNIOR AWARD

From one of the funds created by Mr. Hess, the Council of the Society, upon the recommendation of the Board of Honors and Awards, presents each year a cash award of $50 together with an engraved certificate for the best paper presented and submitted for publication during the previous calendar year, January 1 to December 31, by a junior member, who shall not be more than 30 years old at the time. A paper to be eligible for consideration must be the original work of the author, must not have been previously made public or contributed to any other society in whole or in part, and must be a distinct contribution to the literature of the profession of mechanical engineering.

STUDENT AWARDS

Two annual cash awards of $25 each, together with engraved certificates for the best papers or theses submitted by individual student members on or before June 30 of each year, are presented at the Annual Meeting of the Society after Council action and upon the recommendations of the Board of Honors and Awards, based on the findings of the Committee on Relations with Colleges. Two awards for 1932 and subsequent years have been given, one for undergraduate and the other for postgraduate work.

On or before October 1 of each year, all papers submitted in the competition are read by the Committee on Relations With Colleges and the best one in each category is selected, adjudged from the standpoints of applicability (practical or theoretical), value as a contribution to mechanical-engineering literature, completeness, originality of matter, and conciseness. The authors of these papers are then presented to the Board of Honors and Awards for the respective prizes.

JUNIOR RECIPIENTS

The first presentation of awards from the Hess Funds was made in 1915 to a junior member and in 1916 to three student members. In their subsequent careers, many of the recipients have more than justified their choice by the various committees who made the selections from hundreds of entrants.

1915 ERNEST O. HICKSTEIN, "Flow of Air Through Thin-Plate Orifices."

1916 L. M. MCMILLAN, "The Heat-Insulating Properties of Commercial Steam-Pipe Coverings."

1919 E. D. WHALEN, "Properties of Airplane Fabrics."

1921 S. LOGAN KERR, "Moody Ejector Turbine." Today he is manager of the chemical-engineering division of United Engineers & Constructors, Inc. In the Society, he functions as chairman of both the Hydraulic Division the Committee on Water Hammer.

1922 and 1924 R. H. HEILMAN, "Heat Losses From Bare and Covered Wrought-Iron Pipe at Temperatures up to 800 Degrees Fahrenheit" and "Heat Losses Through Insulating Material." Today, this writer of two winning papers is senior industrial fellow at the Mellon Institute of Industrial Research and represents the A.S.M.E. on Committee C-16 on Thermal Insulation of the American Society for Testing Materials.

1923 SABIN CROCKER and S. S. SANFORD, "The Elasticity of Pipe Bends." At the present time, Mr. Crocker is senior engineer of the engineering division, The Detroit Edison Company. His activities in behalf of the Society have been many, including service as secretary-treasurer and chairman of the Detroit Section, A.S.M.E., general secretary of Detroit Meeting Committee, and Local Sections Delegate to the Annual Meeting. Papers by him were published in A.S.M.E. Transactions for 1930 and 1936.

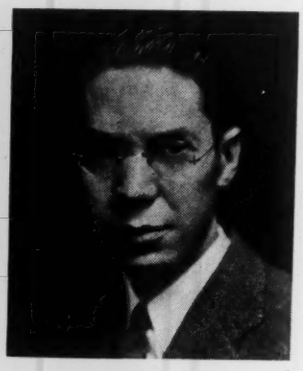
1925 GILBERT S. SCHALLER, "An Investigation of Seattle as a Location for a Synthetic Foundry Industry."

1927 WILLIAM M. FRAME, "Stresses Occurring in the Walls of an Elliptical Tank Subjected to Low Internal Pressure." He is now director of research of the Spang Chalfant Division of The National Supply Company and a member of the Executive Committee of the Pittsburgh Section, A.S.M.E.

1928 M. D. AISENSTEIN, "A New Method of Separating the Hydraulic Losses in a Centrifugal Pump."

The third of a series of articles, prepared under the direction of the Board of Honors and Awards of The American Society of Mechanical Engineers, better to acquaint the members of the Society concerning the honors and awards which are given in recognition of meritorious achievements of engineers.

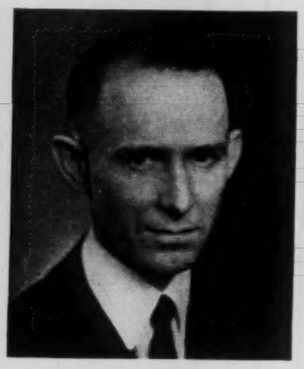
S. LOGAN KERR



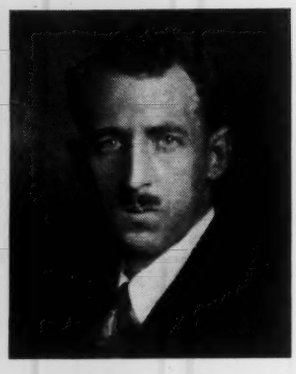
R. H. HEILMAN

W. M. FRAME

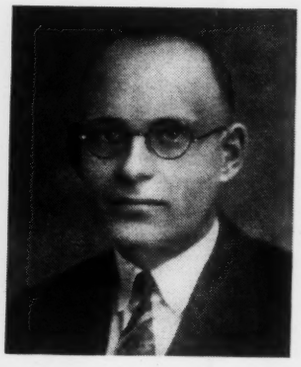
SABIN CROCKER



A. M. WAHL



ED S. SMITH, JR.

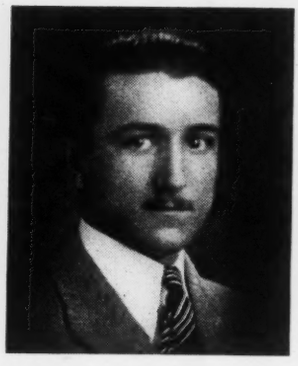


M. K. DREWRY

E. M. WAGNER

J. I. YELLOTT, JR.

S. J. MIKINA



H. F. MULLIKIN

L. J. HOOPER

Recipients of Junior Award

1929 ARTHUR M. WAHL, "Stresses in Heavy, Closely Coiled Helical Springs." Mr. Wahl is research engineer at the Westinghouse Research Laboratories. During the last eleven years he has presented at Society meetings approximately ten papers which were published in A.S.M.E. Transactions and MECHANICAL ENGINEERING.

1930 ED SINCLAIR SMITH, JR., "Quantity-Rate Fluid Meters." Mr. Smith holds the position of mechanical engineer with C. J. Tagliabue Mfg. Co. He has written other papers which have appeared in the Society's publications, and is a member of committees dealing with lettering, standards, fluid metering, and industrial instruments and regulators.

1931 M. K. DREWRY, "Radiant-Superheater Developments." He is employed as assistant chief engineer of power plants, Wisconsin Electric Power Co.

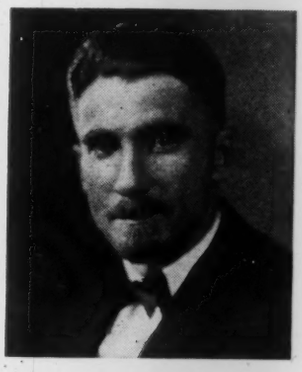
1932 EDMOND M. WAGNER, "Frictional Resistance of a Cylinder Rotating in a Viscous Fluid Within a Coaxial Cylinder." Mr. Wagner, one of the youngest to receive the award, is development engineer and executive assistant in the product research and development department of Kobe, Inc. As a junior member of the Society, he is active in the Junior Group movement in Los Angeles, which he served as chairman in 1938.

1933 TOWNSEND TINKER, "Surface Condenser Design and Operating Characteristics." Mr. Tinker is employed

B. M. GREEN

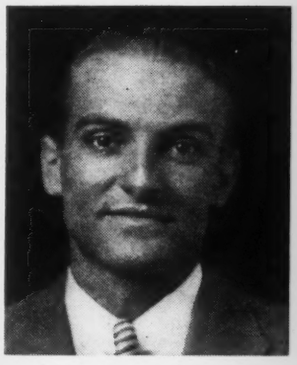
W. E. HELMICK

R. E. PETERSON



R. H. MORRIS

JULES PODNOSSOFF



H. R. HUDSON

C. P. BACHA

D. C. MCSORLEY

L. B. STINSON

Recipients of Student Award

as chief engineer of the Ross Heater and Manufacturing Company.

1934 JOHN I. YELLOTT, JR., "Supersaturated Steam." He is at present an assistant professor of mechanical engineering at Stevens Institute of Technology. His present contacts with the Society are as a member of the Committee on Industrial Instruments. He has served as honorary chairman of the Stevens Student Branch for three years and a member of each year's Annual Dinner Committee.

1935 STANLEY J. MIKINA, "Effect of Skewing and Pole Spacing on Magnetic Noise in Electrical Machinery." Mr. Mikina is employed at present as a mechanical engineer in the electromechanics division of the Westinghouse Research Laboratories.

1936 HARWOOD F. MULLIKIN, "Evaluation of Effective Radiant Heating Surface and Application of the Stefan-Boltzmann Law to Heat Absorption in Boiler Furnaces." The writer of this valuable paper is now an analytical engineer with Babcock and Wilcox Co.

1937 LESLIE J. HOOPER, "American Hydraulic-Laboratory Practice." This young member, besides being assistant professor of hydraulic engineering at Worcester Polytechnic Institute, is also assistant to Charles M. Allen in his consulting work.

1938 ARTHUR CECIL STERN, "Separation and Emission of

Cinders and Fly Ash." Mr. Stern has been an active member of the Metropolitan Junior Group and of the Fuels Division for many years.

STUDENT RECIPIENTS

1916 BOYNTON M. GREEN, Stanford University, "Bearing Lubrication." The student of yesterday is today associate professor of mechanical engineering at Stanford University. In 1932–1933, he was a member of the Executive Committee of San Francisco Section, A.S.M.E.
HOWARD E. STEVENS, Rensselaer Polytechnic Institute, "An Investigation of the Dynamic Pressure on Submerged Flat Plates." Here is another who is back at his alma mater as assistant professor of mechanical engineering.
M. ADAM, Louisiana State University, "The Adaptability of the Internal-Combustion Engine to Sugar Factories and Estates."

1917 H. R. HAMMOND and C. W. HOLMBERG, The Pennsylvania State College, "Study of Surface Resistance With Glass as the Transmission Medium."

1919 C. F. LEH and F. G. HAMPTON, Stanford University, "An Experimental Investigation of Steel Belting."
W. E. HELMICK, Stanford University, "An Experimental Investigation of Steel Belting." Employed at the present time as a gas engineer in the production department of the Shell Oil Company, he has done research work on the superexpansibility factors of natural gases. He is a member of the Los Angeles Section, A.S.M.E.

1920 HOWARD G. ALLEN, Cornell University, "Wire Stitching Through Paper."

1921 KARL H. WHITE, University of Kansas, "Forces in Rotary Motors."
RICHARD H. MORRIS and ALBERT J. R. HOUSTON, University of California, "A Report Upon an Investigation of the Herschel Type of Improved Weir." Mr. Morris has been a member of the editorial department of *Power Plant Engineering* for the last twelve years and is engineering editor today. He is a visitor at many national meetings of the A.S.M.E.

1923 CHARLES F. OLMSTEAD, University of Minnesota, "Oil Burning for Domestic Heating."
H. E DOOLITTLE, University of California, "The Integrating Gate: A Device for Gaging in Open Channels."

1924 GEORGE STUART CLARK, Stanford University, "Two Methods Used for the Determination of the Gasoline Content of Absorption Oils in Absorption Plants."
L. J. FRANKLIN and CHARLES H. SMITH, Stanford University, "The Effect of Inaccuracy of Spacing on the Strength of Gear Teeth."

1925 HARRY PEASE COX, JR., Rensselaer Polytechnic Institute, "A Study of the Effect of End Shape on the Towing Resistance of a Barge Model."
W. S. MONTGOMERY, JR., and E. RAY ENDERS, JR., The Pennsylvania State College, "Some Attempts to Measure the Drawing Properties of Metals."

1926 R. E. PETERSON, University of Illinois, "An Investigation of Stress Concentration by Means of Plaster-of-Paris Specimens." Today, Mr. Peterson holds the position of manager of the mechanics division, Westinghouse Research Laboratories. He is a member of the Executive Committee of the Applied Mechanics Division, Mechanical Springs Committee, and editorial board of the *Journal of Applied Mechanics*, and represents the Society on the A.S.A. Subcommittee on Symbols for Mechanics of Solid Bodies, being chairman of the Committee.

1926 CECIL G. HEARD, University of Toronto, "Pressure Distribution Over U.S.A.-27 Aerofoil With Square Wing Tips—Model Tests."

1927 ALFRED H. MARSHALL, Princeton University, "Evaporative Cooling."
ROGER IRMIN EBY, University of Washington, "Measurement of the Angular Displacement of Flywheels."

1928 CLARENCE C. FRANCK, Johns Hopkins University, "Condition Curves and Reheat Factors for Steam Turbines."

1929 FRANK VERNON BISTROM, University of Washington, "An Investigation of a Rotary Pump."
WILLIAM WALLACE WHITE, University of Washington, "An Investigation of a Rotary Pump."

1930 GERARD EDEN CLAUSSEN, Polytechnic Institute of Brooklyn, "High-Temperature Oxidation of Steel."
HAROLD L. ADAMS and RICHARD L. STITH, University of Washington, "A Wind Tunnel for Undergraduate Laboratory Experiments."

1931 JULES PODNOSSOFF, Polytechnic Institute of Brooklyn, "Pressure and Energy Distribution in Multistage Steam Turbines Operating Under Varying Conditions." For the last two years he has been employed by the General Electric Company in its Buenos Aires, S.A., office as sales and application engineer in the air-conditioning section.

1932 H. E. FOSTER, JR., University of Tennessee, "Factors Affecting Spray-Pond Design" (Undergraduate Award).
WILLIAM A. MASON, Stanford University, "An Experimental Investigation of the Flame Propagation in Internal-Combustion Engines" (Postgraduate Award).

1933 HUGO V. CORDIANO, Polytechnic Institute of Brooklyn, "Thermal Analysis of Lithium-Magnesium System of Alloys" (Undergraduate Award).
JAMES A. OSTRAND, JR., Princeton University, "Sudden Enlargement in the Open Channel" (Postgraduate Award).

1934 HENDRIK REYNOLDS HUDSON, Georgia School of Technology, "Dynamic Balance and Functional Utility Applied to Automotive Design" (Undergraduate Award). Soon after graduation he became professor of physics and astronomy at the Technological High School, Atlanta, Ga., where he is also director of the Tech. High Observatory which he designed and constructed with the aid of his students.

1935 CHARLES P. BACHA, Rutgers University, "The Behavior of Metals Subjected to Combined Stress" (Postgraduate Award). He is employed as test engineer in the experimental laboratory of Hyatt Roller Bearings Division of General Motors Company.
ROBERT W. BEAL, Oregon State College, "Do Lubricating Oils Wear Out?" (Undergraduate Award).

1936 LEON B. STINSON, Oklahoma Agricultural and Mechanical College, "Polymerized Motor Fuels; Their Economic Significance" (Undergraduate Award). Mr. Stinson is a field engineer with the Hughes Tool Company, manufacturers of oil-well drilling and control equipment.
DEWITT D. BARLOW, JR., Princeton University, "The Critical Speeds of Lateral Vibrations of Shafts With Gyroscopic Effects" (Postgraduate Award).

1937 GINO J. MARINELLI, Rensselaer Polytechnic Institute, "Investigation of the Towing Resistance of a Model Submarine Hull" (Undergraduate Award).

1938 MARSHALL C. LONG, Princeton University, "An Investigation Into the Angular Characteristics of an Adjustable-Blade Current Meter" (Postgraduate Award).
DONALD C. MCSORLEY, Michigan State College, "Humidity Insulation" (Undergraduate Award).

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Day by Day

WRITING of day-by-day events a record that cannot be read for a couple of weeks and in the midst of crises that must of necessity affect interpretation of the events themselves has its hazards. Late in the summer there was the threat of war in Europe, narrowly averted, and now replaced by a growing problem in the Far East, and this month the national elections provide the uncertainty. For example, what effect the trend of the elections will have on the general resurgence of improved conditions in the business world dictates caution in statements regarding the record to date. Most commentators hedge around the optimism of their statements a tangle of "if's," "and's," and "but's." As Mr. Roberts puts it in the National City Bank newsletter, "No one would say that a surge of unqualified optimism is sweeping the country. . . . Nevertheless, the business indexes have been moving upward." The National Industrial Conference Board notes gains of 5.3 per cent in total man-hours worked, of 5.5 per cent in pay rolls, of 3.6 per cent in weekly earnings, and of 2.1 per cent in employment in September as compared with August, as reported by manufacturers in 25 industries. Its preliminary figure for unemployment in September was 9,918,000, as compared with 10,593,000 in August and 10,887,000 in July. However, the corresponding figure for September, 1937, was 5,651,000. Dr. Virgil Jordan, president of the National Industrial Conference Board, announced on October 30 that the Board had undertaken "a two-year program of research into the results of private and public management of economic activity in the United States and other countries," the results of which will be awaited with interest.

Wages and Hours

Another experiment in labor legislation was inaugurated in the United States on October 24, when the fair labor standards act, popularly known as the "wages-and-hours" law, went into effect. Administration of the act is under the direction of Elmer F. Andrews, a civil engineer and graduate of Rensselaer Polytechnic Institute, who gave up his post as New York State Industrial Commissioner to take on the new federal job. Comment on the manner in which Mr. Andrews has approached his task has been favorable. It has been the history of other important pieces of legislation of a social and economic nature that much depends on the attitude of the administrators and manner in which they exercise their functions. Mr. Kennedy ushered in the S.E.C. with a minimum of disturbance and retired from his post with the good will of most of the country. On the other hand, the National Labor Relations Board has found itself in hot water most of the time; it has been assailed from all sides, and amendment of the Wagner act, which it administers, has become a major issue before the country.

The law Mr. Andrews is to administer aims at placing a "floor" under wages and a "ceiling" over hours of work. At present these limits are set at 25 cents per hour and 44 hours per week. In the next year the minimum wage is to be raised to 30 cents an hour, where it will remain for six years. The work-week standard is to be 42 hours in the second and 40 hours in the third year of operation. These provisions are less drastic and are to be introduced more gradually than those which threw France into such economic difficulties last year that they had to be changed. They are elements in a national shift that engineers must reckon with.

Railroad Labor

Another trend of the times that engineers might ponder is the recent abandonment of the railroads' wage-reduction efforts following the report of the President's emergency fact-finding board. For the first time the special mechanism instituted some years ago for dealing with labor disputes in the railroad field reached the final stage of review provided in the law. The railroads lost their case, and the proposed wage cut was withdrawn, since, obviously, public opinion would not be favorable to the success of such action in the light of the report. But the basic problem of the railroads was not settled, and as a result some kind of remedial action is forecast. A special joint management–labor committee, appointed by the President, has been at work. The task of financing the purchase of railroad equipment, of large-scale consolidations, and of the revision of working rules is being attacked. Chances that the next Congress will provide some form of legislative reform are said to be good. Any relief that will permit the railroads to assume a more active part in the markets of industry will provide opportunities for engineers.

National Defense

Twenty years ago an armistice was concluded between contending powers in Europe and the world was made "safe for democracy." Today the democracies find themselves far from safe, and the spirit of democracy is a wavering wraith. Realistic persons acclaim the events at Munich as foreshadowing "peace in our time," on the one hand, and on the other, they feverishly increase the tempo of the greatest drive for national defense and preparedness the world has ever known. Jittery from having its ears glued to the radio for the fateful decisions being arranged in Europe, inhabitants of the ocean-isolated United States allowed themselves to be thrown into a panic last month by a fantastic broadcast reporting an invasion, not from the other side of the water but from another planet. Mr. Baruch returned from journeying in distant lands to call attention to the dangers he foresaw to peace and security and to what he considered the critical part South America played in the threat to our safety. From Washington have come announce-

ments of programs of national defense, of cooperation between industry and the government in plans for industrial mobilization, referred to by Assistant-Secretary of War Louis Johnson at the Providence Meeting of The American Society of Mechanical Engineers (see MECHANICAL ENGINEERING, November, pages 882–883), of the reopening of navy yards and plants, of plans to increase the effectiveness of the branches of the service concerned with naval design, of proposals to multiply the number of aircraft, to equip the army with a more effective rifle, and to assist the electrical industry in installing new generating capacity so that the workshops need not suffer for lack of power should open hostilities demand wartime production. From several parts of the country, according to the newspapers, requests have been received for antiaircraft protection, stimulated, no doubt, by the fears engendered by the Orson Welles broadcast and the many successful flights of aircraft across the Atlantic Ocean.

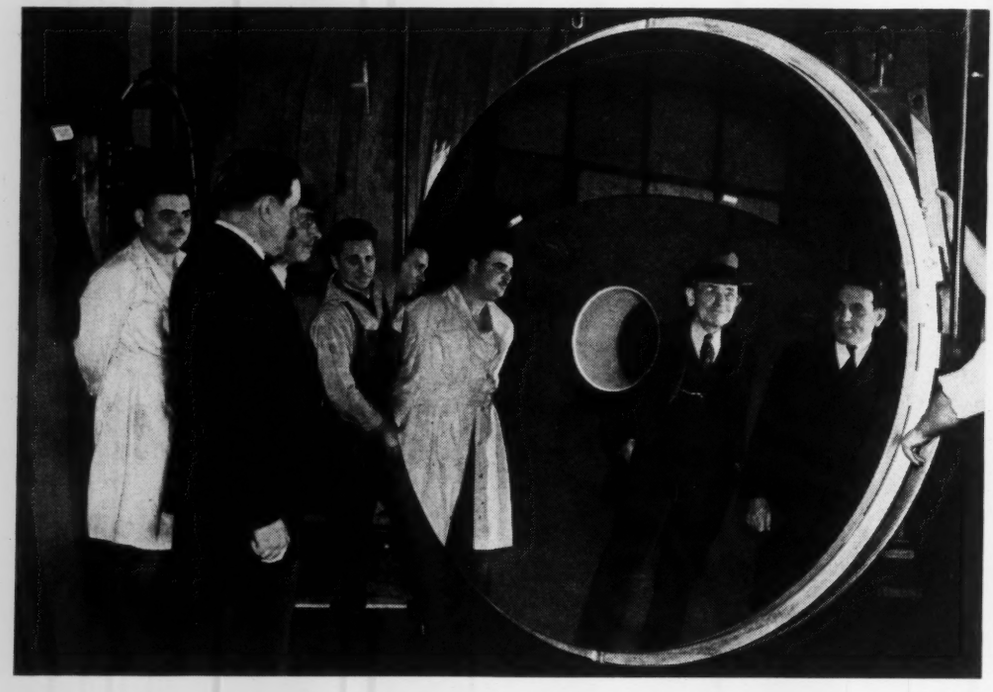
What it all means is not a little confusing. How many of the plans and proposals will ever advance into the stage of actual development, none can guess. The world has seen unemployment swallowed up in a shortage of workers in European countries by preparations for war and has been told that the demand for engineering talent has placed the engineer in a preferred position in Central Europe. Thus, in this country, any national-defense or preparedness program will have its effect in decreasing unemployment and in increasing the need for engineers. As in Europe, so it may happen here, that it will be hard to determine how much of the impending improvement in industry will be the result of healthy economic recovery from a postwar depression and how much must be charged against the preparations for a new war. Fortunately, in so far as technical progress is concerned, the acts of war make their contributions as well as the ways of peace. Turbine and aeronautical designers may make as much progress working for a national-defense program as they would in meeting the demands of peaceful industry. In any event, it looks as though those who have been predicting that there is nothing more for scientists and engineers to do are, once more, going to find themselves in error.

Auto Show

Heralded by weeks of advance publicity on new models and by previews in New York of the 1939 motorcars, the automobile show opened in the Grand Central Palace on November 11. Some of the high lights of this year's cars are noted on page 970 of this issue.

Cooper Union Installation

At Cooper Union, in New York City, on November 3, a new director was installed in the presence of several hundred representatives of the country's educational institutions and learned societies. Bishop Manning pronounced the invocation and benediction, that peerless speaker, Nicholas Murray Butler, Columbia's famous president, delivered an address on the significance of Cooper Union, Karl T. Compton, president of M.I.T., spoke in terms of high praise of the new director, Gano Dunn, president of the Board of Trustees, read the charge, and the entire audience joined in singing a hymn written by Rossiter W. Raymond, American mining engineer, who was consulting engineer to the firm of Cooper and Hewitt and a close confidant of Peter Cooper, founder of the Union, who, during the last year of his life, was an honorary member of The American Society of



82-INCH, 3-TON MIRROR, MADE OF PYREX GLASS, 12 INCHES THICK, AND THE MEN WHO HAVE BEEN CARRYING ON GRINDING AND POLISHING OPERATIONS SINCE OCT. 30, 1934, IN THE WARNER & SWASEY OPTICAL DEPARTMENT. THE MIRROR, WHICH IS FOR THE NEW MCDONALD OBSERVATORY, IN TEXAS, DESCRIBED IN "MECHANICAL ENGINEERING," JUNE, 1935, HAS A HIGHLY REFLECTIVE ALUMINUM SURFACE APPLIED OVER A COATING OF CHROMIUM BY AN ATOMIC BOMBARDMENT IN A SPECIAL CELL

Mechanical Engineers. The object of the services was the installation of Edwin Sharp Burdell, until recently dean of humanities at Massachusetts Institute of Technology. A young man who was graduated from M.I.T. in 1920 and attended the Harvard School of Business Administration, Dr. Burdell received the degree of M.A. from The Ohio State University in 1929 and of Ph.D. from the same institution in 1934. In his installation address Dr. Burdell said that "scientific humanism" should be the driving force of schools of the future. He defined scientific humanism as "a marriage of science and the accumulated culture of the past. . . . It must be a fusion, a synthesis, a union out of which is born the intellectual life of the future. In a word, this means that we must have liberal-arts teachers who know something about science and science teachers who have some feeling for the arts. . . . It is reasonable to hope that the Cooper Union graduate of the future will be not merely an engineer, an artist, or a social philosopher, but a well-rounded man who has intellectual associations with fields other than his own."

Power of the Press

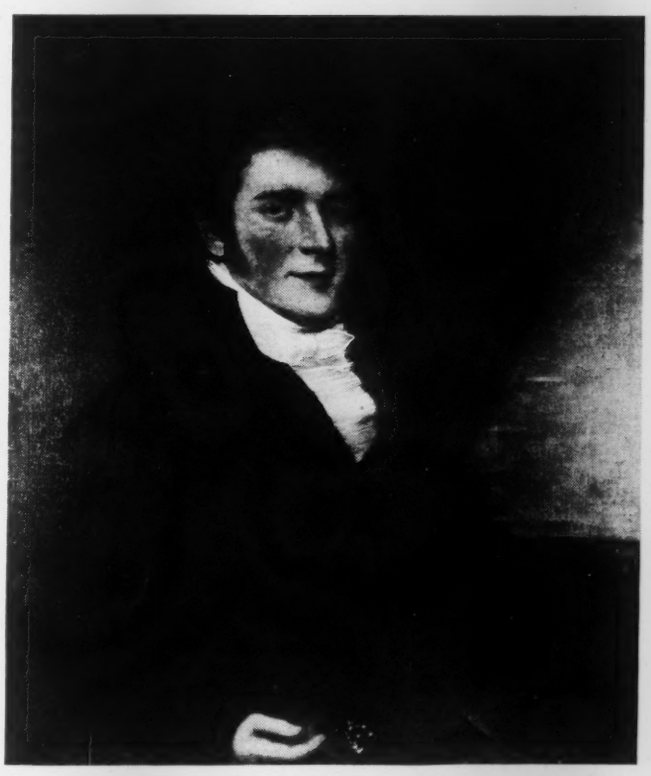
Some years ago the *New Yorker* published a quip about needing a gas mask to get past the underground hot-dog stand in going from the Grand Central Terminal to the Yale Club. Almost immediately that exotic reminder of the open countryside disappeared, and when the steel shutters rolled up once more the subterranean cubicle was found to be inhabited by one of those clever needleworkers who reweave the parts of your clothes that are burned by cigarette or pipe ashes. In its issue of November 5, the *New Yorker* discloses the fact that the best of the self-portraits of Robert Fulton "hangs behind the door in Room 1103 of the Engineers Society Building on Thirty-ninth Street. It was donated," our contemporary explains, "to The American Society of Mechanical Engineers in 1897, and filled a position of honor in the president's chamber until six months ago, when it was superseded by a bronze plaque of a man who helped get the building erected."

Possibly the *New Yorker's* well-bred reproach will bring the Fulton portrait out from behind the door just as its comment on the odor of hot dogs closed the stand in the Grand Central, but our immediate amends shall be on a broader scale. After all, whether it is behind the door in a public room, or honorably displayed in a semiprivate office, the portrait can be seen only by those who stand in front of it. So that all may see, if not the portrait itself at least a reproduction of it, we present the accompanying illustration.

Robert Fulton died before The American Society of Mechanical Engineers was founded, and hence never honored the Society by membership in it. But his name is cherished by all engineers because of his association with the steamboat. "Association" is one of the weasel words used advisedly in deference to those who put forward claims for Stevens, Fitch, Rumsey, and others whenever someone mentions Fulton, as the *New Yorker* did, as the inventor of the steamboat.

Other cherished memories of Fulton are owned by the Society. One of these is a dining-room table, formerly used by the famous engineer and artist, and another is an autographed brush drawing of a high-level canal that hangs, not behind a door, but in a rather dark passage between the public rooms and the staff offices.

If you get through the passage into the main office that lies beyond, you will find hanging on the east wall a framed working drawing of "the Sound Steamer *Fulton* and estimate of cost," by Robert Fulton. This drawing is also reproduced on a bronze tablet on the Fulton Memorial in Trinity churchyard, New York City, erected with funds raised by a Society committee and dedicated as part of its Annual Meeting of 1901.



SELF-PORTRAIT OF ROBERT FULTON THAT HANGS IN THE ROOMS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Carefully preserved in the library is a set of Fulton drawings, discovered some years ago when the British journal, *The Engineer*, moved its offices. Apparently these were made for patent application, and are a duplicate of the set destroyed when the United States Patent Office burned in 1836.

Science Writers

It is a pleasure to report that the Clement Cleveland Medal "for outstanding work in the campaign to control cancer" has been awarded to the National Association of Science Writers. This group that serves the newspapers and news syndicates by interpreting science as it comes into the news has been performing a valuable service, not only in the field of medicine and surgery, but in all branches of science. Anyone who has seen these writers at work at one of the large scientific gatherings when dozens of papers must be intelligently abstracted for tomorrow's paper will appreciate the high order of skill and care that must be exercised in the work.

Anniversaries

On October 17 the General Electric Company celebrated its sixtieth year. In Schenectady the Chamber of Commerce presented the company with a bronze plaque, commemorating steps leading to the formation of the company and its location in Schenectady.

The fifteenth anniversary of the world's first continuous-sheet

mill, built at Ashland, Ky., in 1923 by the American Rolling Mill Company, was celebrated on October 19.

On Jan. 7, 1839, at a meeting of the Académie des Sciences, France, photography was mentioned for the first time. Commemoration of this important event will be celebrated on Jan. 7, 1939, in this country and abroad.

A.S.A.

Twenty years of standardization are summarized in *Industrial Standardization*, organ of the American Standards Association which was formed October 19, 1918, as the American Engineering Standards Committee, a direct outgrowth of a committee of The American Society of Mechanical Engineers, dating back to 1911, which had proposed that a national agency be set up for the "registration" of the standards of the technical and industrial groups of the country.

Today, the American Standards Association has a membership of 71 national organizations and about 2000 companies. Its 2987 committee members represent more than 600 cooperating organizations. Action taken by the board of directors in October, 1938, on a request from the Chamber of Commerce at Buenos Aires, to station a standards engineer in Argentina, has recently been announced. Dr. P. G. Agnew, secretary of the A.S.A., was recently elected an honorary member of the American Home Economics Association for his part in organizing work on standards for consumer goods.

The 1939 Automobiles

S.A.E. JOURNAL

NOVEMBER brings the automobile show and also Austin M. Wolf's annual review, "Trends in Design of 1939 Cars," in the *S.A.E. Journal*. While it is impossible to present a complete summary of this closely packed article, a few high lights are noted in what follows.

The many improvements in the new models can be classified under safety, comfort, economy, and styling—with accent on safety. Improved vision, lower center of gravity, more effective controls, instruments, and indicators that truly impart a message, are a few of the results of the industry's major interest.

Roomier bodies, sunshine tops, improved suspension, easier controls, and better ventilation assure comfort. Economical operation is brought about by weight reduction, improved carburetion, further adoption of the improved overdrive, and the special finish and treatment of engine parts. Advanced styling shows a smooth unity of form initiated at the tip of the front, in its unbroken sweep of the rear, concealed door hinges, the removal of skirting of running boards, and a balanced ornamentation of metal trim.

The Ford "Mercury" 95-hp V-8 on a 116-in. wheel base is the noteworthy new car. The Mercury-8 crankshaft-mounted cooling fan has a centering flange giving a $^1/_4$-in. bearing on a hub member, and is driven therefrom by frictional contact with a rubber ring at each side. Crankshaft-mounted fans are also used on the Ford "De Luxe" and the Oldsmobile.

In the clutch field, Borg and Beck has developed a driven plate in which there is a large reduction in polar moment of inertia, materially improving gear shifting, which is particularly important in the prevalent remote-control type of gearshift. Instead of the usual disk between the facings, there are only the cushion members which are riveted to a small-diameter disk carrying the hub springs. The cushion members or springs are riveted to extend radially outward from the center disk between the facings, and the wave-type springs are riveted to each facing on alternate waves in the spring.

The Chrysler "Custom Imperial" is equipped with a fluid flywheel.

Gearshift control under the steering wheel is practically universal, either as standard or optional equipment. Chevrolet provides an optional vacuum shift developed by Bragg-Kliesrath in conjunction with Chevrolet engineers. In Packard transmissions all gears are in mesh and are of the helical type except for the reverse spur gear train with its sliding gear on the main shaft. The Warner Gear overdrive used by Studebaker, Chrysler, De Soto, Nash, Graham, Hupmobile, and Packard now provides a means for cutting out the overdrive and returning to direct at the will of the driver. Warner Gear has developed a synchronizer requiring a minimum amount of shift effort in view of remote controls. Oldsmobile retains the automatic transmission and this has been improved by softening the downward shift from third to first as the car approaches a stop. Yellow Coach and Spicer have developed jointly a Ljungstrom type of hydraulic converter for bus use in which there is a friction clutch between the flywheel and the converter, a reverse gear back of the converter, a roller clutch to disconnect the hydraulic system when in direct drive, a direct-drive positive clutch, and a fluid cooling system.

Hydraulic brakes have been adopted by Ford and Overland, and Buick and Packard offer the NoRol unit as optional equipment.

Cadillac has introduced the Hi-Plane Hotchkiss drive. Pontiac's variable-rate rear spring utilizes a three-leaf auxiliary spring below the main spring. Chevrolet has gone to the parallel-link method of front suspension. Coil springs are utilized in the Oldsmobile rear suspension. Buick's emblem on the trunk lid is in the form of a flashing direction signal operated by a small flip switch on the gear-shift lever and with a pilot light at its left. A metal-encased Tung-Sol current interrupter provides a flashing rate of 85 to 90 per min.

Plastics are used to a considerable extent in the new instrument panels with speedometer and instruments immediately in front of the driver, often combined under one glass. The safety-signal speedometer, used in the Chrysler products and built by Auto-Lite, provides a Lucite button on the pointer disk and glows green up to 30 mph, yellow between 30 and 50 mph, and red thereabove.

Improvements in heating and ventilating arrangements are to be noted on many cars. The Lincoln "Zephyr" type of grille with louverless hood has been adopted by "Mercury," Ford "De Luxe," Studebaker, and Buick. Retaining the center grille, though of lower and restricted opening and supplemented by side grilles in the fender apron, are Cadillac, Chevrolet, Chrysler products, Hudson (except the "112"), Oldsmobile, Nash, and Pontiac. Bodies are in general lower, wider, roomier, and with better vision. The sunshine top, available on many General Motors cars, marks the partial adoption of a popular foreign type. Trunk capacities have increased.

A replacement four-cylinder Diesel for Ford V-8 trucks has been developed by Hercules particularly for export use. Cylinders are $4 \times 4^1/_2$ in.; displacement, 226.2 cu in.; compression ratio, 16 to 1; and the engine develops 70 hp at 2600 rpm and a maximum torque of 162 lb-ft at 1400 rpm. Hercules is now working on a six-cylinder, 5×6-in. flat Diesel. Dodge has available for its 3-ton truck a six-cylinder, $3^3/_4 \times 5$-in., 331 cu-in-displacement Diesel equipped with Ex-Cello pump, pintle-type nozzles, and automatic injection timed according to engine speed. The Mack-Lanova is a six, $4^3/_8 \times 5^3/_4$-in., 519-cu in. displacement, developing 131 hp at 2000 rpm, a maximum

torque of 381 lb-ft between 1200 and 1450 rpm, and a bmep of 110 lb per sq in. Waukesha has produced an Overland series of six-cylinder Hesselman engines of $5^3/_4$ and $6^1/_4$ in. bore and $6^1/_2$ in. stroke, developing 172 and 202 hp, respectively, at 1850 rpm.

Twin Coach Co. has developed a "Super-Twin" consisting of two 35-passenger bodies joined together back to back with large rubber hinges just below the floor line. Floor movement in going over ramps or depressions is absorbed by a collapsible rubber seam which contracts and expands only to the extent of $^7/_{16}$ in. At the roof line the ends of the two bodies have an 11-in. maximum movement, and this section is bridged by a rubber diaphragm made especially to stretch in the longitudinal direction; this stretch amounts to only a few inches over ordinary city streets. Two dual-tired driving axles are located in the center and can be powered either by Diesel-electric or trolley bus equipment. The electric driving motors in either case are located approximately amidships of each body unit. The Diesel bus is powered with a Hercules model HXB, 5 × 6-in. engine.

Utilizing the basic principles of the ice engine for railway service, Waukesha in conjunction with Tropic-Aire, has developed an air-conditioning system used by Greyhound.

Equation of State for Steam

ENGINEERING

USING results of steam research carried on at the Masaryk Academy of Work, Prague, Czechoslovakia, under the direction of Jaroslav Havlíček and Ladislav Miskovsky, Jan Juza developed an equation of state for superheated steam for the range from 250 to 550 C based on actual measurements. However, for the lower temperatures the values were extrapolated. During 1936 and 1937 several reports were published in Germany, Great Britain, and the United States, containing definite results of other measurements, and these enabled Dr. Juza to reformulate the equation so that in its present form it is based on measurements over the range from 50 to 550 C, and is extrapolated only for lower and higher temperatures. A description of the methods used in revising the previous equation is described by Dr. Juza in an article appearing in the July 1 and 8, 1938, issues of *Engineering*, from which the proposed new equation, which follows, was obtained.

For technical purposes the equation of state should be of the form

$$v = f(pT) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

from which the equations for enthalpy and entropy can easily be derived. Finally, Mollier's diagram is drawn, this being of great help to those interested in technical science. The existing theoretical considerations are not sufficient to determine precisely the form of the equation of state. As far as steam is concerned, the problem is complicated by the fact that in all probability the polymerization of steam molecules or, using Professor Callendar's expression, the coaggregation of the molecules, takes place. This phenomenon obviously increases with decreasing temperature and increasing pressure. Consequently, the engineer can only calculate the specific volume at $p = 0$, and therefore it must be assumed that the molecules at $p = 0$ are not coaggregated. This assumption agrees well with measurements of specific volume at low pressures. It is possible to determine the specific heat at $p = 0$ by means of the quantum theory, but it is necessary to choose the form of the equation of state empirically so that it may be consistent, as far as possible,

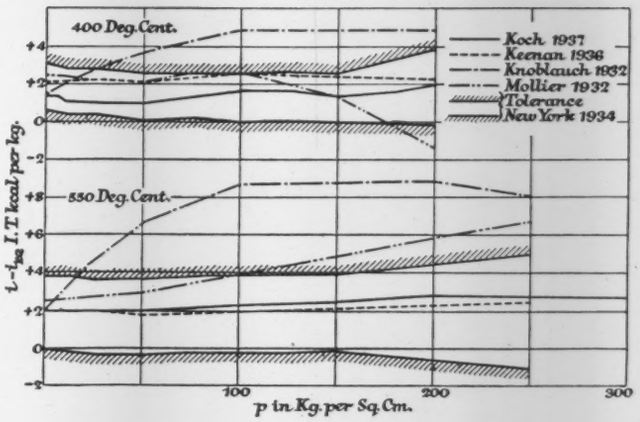


FIG. 1 COMPARISON OF ENTHALPY VALUES FROM STEAM TABLES WITH DATA COMPUTED FROM EQUATION [4]

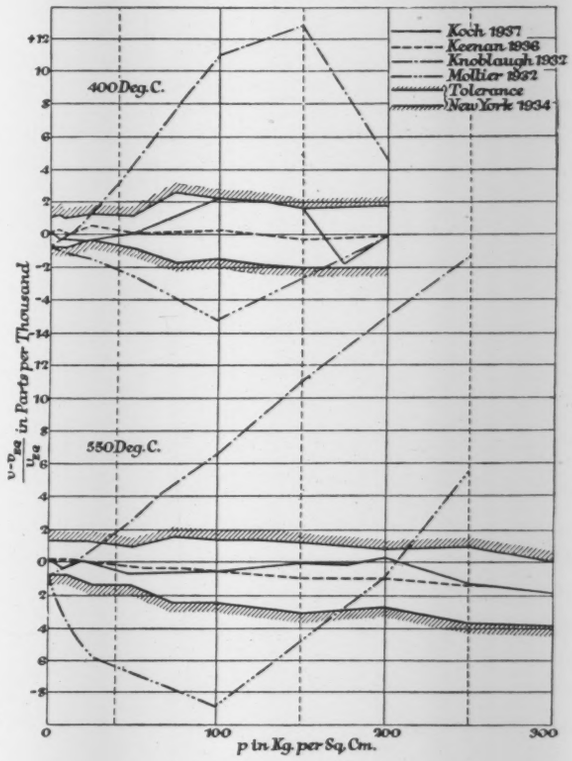


FIG. 2 COMPARISON OF SPECIFIC VOLUMES FROM STEAM TABLES WITH DATA COMPUTED FROM EQUATION [2]

with the measured values. It will be evident that to increase the precision of the equation of state and the range over which it can be applied, it is necessary to choose a form of increasing complexity.

After many experiments, the following form of the equation of state was chosen:

$$v = \frac{RT}{p} - \left[a_0 + a_1\left(\frac{p}{10^6}\right) + a_2\left(\frac{p}{10^6}\right)^4 + a_3\left(\frac{p}{10^6}\right)^{16} \right] \ldots [2]$$

where the gas constant $R = 47.05$ m per deg C, T is the absolute temperature ($273.2 + t$ deg C), p is the pressure in kg per sq m, and v the specific volume in cu m per kg. a_0, a_1, a_2, and a_3 are the functions of absolute temperature. From this equation of

state the enthalpy, or total heat, may be calculated by means of the thermodynamic relationship:

$$\left(\frac{\partial i}{\partial p}\right)_T = -AT^2\left(\frac{\partial \frac{v}{T}}{\partial T}\right)_p \quad \ldots\ldots\ldots\ldots [3]$$

where $A = 1/426.99$ kcal per kg-m, is the mechanical equivalent of heat. After substituting Equation [1] in Equation [2] and after integrating Equation [2], there is obtained the following equation for the enthalpy

$$i = i_0 - \left[b_0\left(\frac{p}{10^6}\right) + b_1\left(\frac{p}{10^6}\right)^2 + b_2\left(\frac{p}{10^6}\right)^5 + b_3\left(\frac{p}{10^6}\right)^{17}\right] \quad \ldots [4]$$

where i_0 = the enthalpy at $p = 0$, and b_0, b_1, b_2, and b_3 are the functions of absolute temperature.

Figs. 1 and 2 give the comparison of the enthalpy and of the specific volumes based on different steam tables, published in metric units, with values computed from the proposed equation of state. The great progress made since 1932 is at once evident. The Keenan-Keyes Tables of 1936 and the Koch Steam Tables of 1937, show deviations which amount to only a small part of the deviations of 1932.

Doodlebugging

PETROLEUM WORLD

GEOPHYSICAL exploration today utilizes various modern scientific instruments to aid in the discovery and location of oil beds. Yet, strangely enough, in and around the principal oil-producing areas in the United States, according to an article by George C. Williams in the September, 1938, issue of *Petroleum World*, many holes (intended to be oil wells when drilled to predetermined depths) are still located by persons known technically as rhabdomantists and popularly as "doodlebuggers," all of whom claim new and novel (and generally very secret) methods of locating petroleum. In addition to predetermining the depth at which oil-bearing sands will be found, it is the general practice to forecast the volume of production and the gravity of the oil.

In tracing the history of rhabdomancy or doodlebugging, Mr. Williams first quotes definitions of the two words as contained in the dictionary. Rhabdomancy is defined as, "divination, as for the discovery of springs, precious metals, etc., by means of a divining rod," its derivation being from the Greek words *rhabdos* meaning rod and *manteia* meaning divination. Doodlebug is defined in a liberal way as, "any unscientific device, with which it is claimed that the minerals, including petroleum, water, etc., may be located."

Greek mythology mentions divining trees and the fact that forked branches removed from these trees continued to maintain the power and divining properties even though severed from the parent stock. But when those first divining trees were no longer available some other material necessarily had to come into use. For some time wood, especially hazel, was the accepted material and many allusions were made to it even before the publication of Agricola's *De Re Metallica* in 1556 in which he pointed out that the rod does not move in the hands of all men and thus the phenomenon must be due to some quality of the doodlebugger himself. That same observation has been made by many persons since. The work of Sebastian Münster, *Cosmographia Universalis*, published in 1550, contains the earliest picture of a doodlebug artist at work.

In later times, almost any material was used as long as it had length to allow easy perception of movement and sufficient smallness of diameter to give it flexibility or suppleness. The exact shape rapidly began to lose importance. Such queer articles as watch springs, candle snuffers, scissors, and even German sausages apparently made excellent doodlebugs—at least one could eat the latter, if he didn't find an oil field.

The present-day doodlebug is generally encased and the "working parts" hidden from view—the more to convince the gullible—although some still work "in the open." Some doodlebuggers even go so far as to disdain the use of such a medium as a forked stick, bent piece of wire, spring, or other device, depending upon their own physical (or should it be psychical?) reactions when over an accumulation of petroleum.

Filtration

1938 ANNUAL MEETING, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

NO MATTER what the industry, industrial filtration in one form or another is used in the manufacture of many everyday products, such as metals, sugar, paper, ink, gasoline, and oil. The process also helps in the purification of rivers and lakes and of boiler feedwater. Because of the growing importance of filtration in mechanical processes, a Mechanical Separation Committee was formed this year by the Process Industries Division of The American Society of Mechanical Engineers. As its first major effort, the Committee is arranging a session on the subject at the 1938 Annual Meeting of the Society in New York, Dec. 5–9. Among the papers to be presented at this session is one by Edward D. Flynn, member A.S.M.E., on "Filtration Trends," from which the following has been abstracted:

All filters operate by differential pressure. Usage divides them into three general classifications and provides distinguishing names for each, the name depending upon the nature of the pressure differential.

The first type is the percolation filter, in which the actual hydrostatic head of the column of liquid above the filter medium creates the only pressure used. One example is the sand filter of the modern water-purification plant, another is the sand percolation vat of the metallurgist or chemist.

In the second type, pressure differential is obtained by partially evacuating the air from one side of the filter medium and allowing the atmospheric pressure on the other side to push the liquid through the medium. This is called a vacuum filter. In the third type, differential pressure is obtained by pumping the slurry into the filter. This is known as a pressure filter.

The vacuum type is a continuous filter. The pressure filter may be either continuous or batch, and the percolation filter is a batch type. The terms, continuous and batch, are derived from the methods of operating the filter. Continuous filters are so termed because, while they are in operation, the solid particles in the material being filtered are continuously deposited upon, and also continuously removed from, the filtering medium. In batch filters, the solids are continuously deposited on the filter medium, but removed only at intervals when the filtration must be stopped.

The filter medium is that part of the filter upon which actual separation of solids from the liquid takes place. It may be cloth of cotton or wool, metal, glass, or a layer of sand, diatomaceous earth, or other porous material. The main qualifications are that the medium shall allow the liquid to pass freely

and yet retain the suspended solids, and must withstand chemical attack by the materials handled.

In order to overcome the disadvantage of stopping the batch filter to remove the caked solid and to wash the filter medium, the continuous pressure filter was developed. This type continuously discharges part or all of its caked solids and provides means for continuously removing the discharged cake. A disadvantage in this method is that due to the feeding of slurry and discharging of cake in the same chamber, some intermingling takes place. A wet discharge results and, as this type filter is used for clarification of the filtrate, a loss of filtrate occurs in the wet cake discharged.

A study of the various applications of filters shows that design trend has followed closely that of all process-industry equipment. Continuity of operation and reduction of operating labor have been the major factors in development. In addition there have been changes in materials of construction to overcome corrosion problems created by new processes or to meet the increased demand for greater equipment life in old industries.

Recent design developments in filters have been primarily concerned with clarification filters, i.e., where clarification of the filtrate is of prime importance. Since most clarification operations require a closer filter medium than cloth to remove the very finely divided particles of suspended matter, a relatively thick layer of diatomaceous earth or filter cel has been utilized for this purpose. This layer is called a precoat because it is formed before actual filtration takes place. The advantage of precoat filtration is the excellent clarity of filtrate produced by having the liquid pass through the minute interstitial spaces in the filter cel which retains the finely divided solids. The disadvantages of this method, which has been in use for many years, is that the outer surface of the filter cel becomes clogged in a short time with the fine solids, resulting in a rapid falling off of the filtration rate. Another disadvantage is the loss of part of the filter cel when the caked solid is discharged.

This problem has been solved by the development of the so-called continuous precoat filter, either of the vacuum or pressure type. During filtration, a very thin layer of the outer surface of the precoat, together with the solids deposited thereon, is continuously removed by an automatically advancing shaving knife. The consumption of filter cel is reduced to a minimum by limiting the cut of the shaving knife as little as 0.002 in. Consequently, striking economies in the use of precoat material have been accomplished by this new method.

In addition to the mechanical design, problems of operation have been solved satisfactorily, such as the proper application of the precoat layer, the prevention of cracks during and after the formation of the layer, and the control of compression of the layer as vacuum or pressure increases. Materials heretofore outside the realm of successful filtration are being handled today with comparative ease.

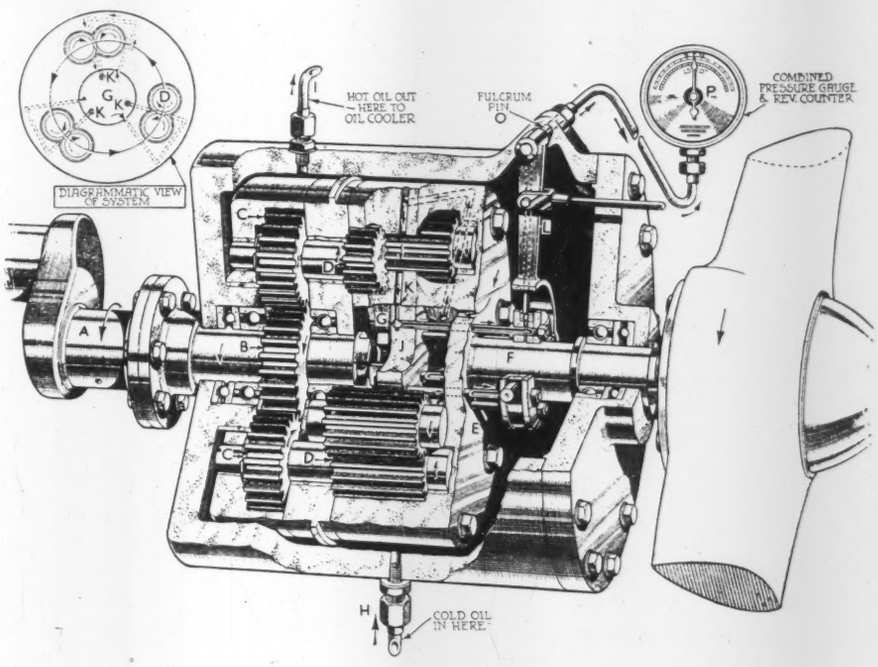

DIAGRAMMATIC VIEW OF SYSTEM
HOT OIL OUT HERE TO OIL COOLER
FULCRUM PIN
COMBINED PRESSURE GAUGE & REV. COUNTER
COLD OIL IN HERE

FIG. 3 THE CARTER VARIABLE GEAR FOR AIRPLANE ENGINES

A Variable Gear for Airplanes

THE AEROPLANE

HYDRAULIC and so-called "gearless" transmissions have been described in this and other publications recently. Consequently, it is interesting to note in *The Aeroplane* for Sept. 21, 1938, an article describing a new hydraulic transmission system and fluid dynamometer, designed specifically for airplanes. Invented by J. Carter, an English engineer, the unit is said to combine the qualities of a variable-speed gear, a vibration damper, and a dynamometer. Use of this variable-speed gear in conjunction with an airplane engine makes it possible to run the engine at constant speed with a fixed-pitch propeller.

The transmission consists of a train of epicyclic gears controlled by oil under pressure. As shown in Fig. 3, it is quite simple in its essentials. The crankshaft *A* drives the pinion gear *B* which in turn drives other pinion gears *C*. These in their turn drive the gear pumps *D*. The shaft *F*, through which the drive is finally transmitted to the propeller, is coupled to the pump housing of the driven unit *E*. The central chamber *G*, inside the pump housing *E*, forms a fluid reservoir for the gear pumps and is supplied with oil under pressure through the pipe *H*. The oil is then returned through the pipe *I* to an oil cooler or to the crankcase or oil sump of the engine.

The volume of oil which is allowed to flow through the pumps is controlled by the piston valve *J*, as it slides across the discharge ports *K*. When the valve is in a central position the ports are fully opened and there is no resistance to the oil flow, thus allowing the pinions *C* to rotate freely. But as the piston valve is moved across the ports by a lever *L*, the resistance to the oil flow is increased and the drive is transmitted from the engine to the propeller. Then when the ports are completely closed the unit rotates as a whole, and so provides direct drive from the engine to the propeller.

The oil feed to the gear pump *D*, under pressure, damps out any engine vibration by the cushioning effect of the oil between the teeth of the gear pump. The effectiveness of the damp-

ing action can be adjusted by moving the piston to a suitable position across the discharge points.

The pressure at which the oil is supplied to the transmission varies with the speed of rotation and, consequently, with the output of power. Thus by calibrating the horsepower and the corresponding speed of the engine with the pressure in the oil system as indicated by a gage, the transmission could be made to serve as a fluid dynamometer.

Spun-Rayon Merchandising

A.S.M.E. FALL MEETING AT PROVIDENCE

POINTING out the rapid advance in the use of fabrics made from cut rayon staple, Dr. S. J. Kennedy, director of market research, Pacific Mills, in a talk presented at the Fall Meeting of The American Society of Mechanical Engineers in Providence, R. I., Oct. 5-7, 1938, reviewed the problems involved in merchandising fabrics made from new fibers, using for his example fabrics of spun rayon. This new fiber, known for a number of years, began to emerge from its obscurity in 1935 and to cut a swath in the textile markets at a rate that is said to have been literally astounding. Within the bare space of three years, spun-rayon fabrics made from cut rayon staple have been introduced into practically all of the markets where filament rayon has been used in the past and into new markets in which filament rayon never seemed able to get a foothold.

It might seem to some people unnecessary to take a continuous filament, chop it up into short lengths, and then reassemble and spin the fiber into a continuous yarn again. There are good reasons, however, why this is desirable. In the first place, it is possible to produce rayon-staple fiber more cheaply than filament yarn; currently the prices are about 24½ cents for rayon staple as compared with 50 cents for continuous filament yarn. The reason for the difference is that the extreme care and precision required in filament yarn are not needed for the production of cut staple, and furthermore, there is no cost of winding, reeling, and the like. This low price of spun-rayon staple helps to bring it within the realm of cotton.

Almost equally important, Dr. Kennedy noted, is the fact that the rayon staple can be spun to resemble practically any of the other fibers, cotton, wool, or flax. It can be mixed with the other fibers to insure greater resemblance to them or can be used independently by itself. Here, then, is an intensification of the kind of competition which filament rayon introduced against silk and which can be turned against all of the other fibers. It is price competition from a fiber which in woven fabrics has closely similar physical characteristics to all of the other fibers. In the countries of Europe which are attempting to achieve economic self-sufficiency, and in Japan, spun rayon is being made to serve almost exclusively for the other fibers and, on the whole, does fairly well.

The big question to the textile industry today is, then, where spun rayon is going to fit into the picture and how much of a market will ultimately be left for the other fibers, for the possibility exists that the synthetic fibers, under continued improvement and gradually lowering costs of production, may, even in this country, supplant in large measure the natural fibers. What are the merchandising limitations, advantages, and markets for spun-rayon fabrics?

In constructing fabrics of a new fiber like spun rayon, where its actual performance under all conditions is still subject to demonstration, there are few standards to follow and a great deal of leeway in possible qualities which producers of differing ideas may try out. It must be expected that there will be a large number of fabrics on the market of widely varying construction, some qualified to meet consumer uses and tests, others not so qualified. But fortunately, as techniques of fabric production and finishing gradually improve, there can be expected an increasing uniformity of serviceability in spun-rayon fabrics, such as has now been attained in filament rayon.

At the present time the largest proportion of spun rayon is going into women's outerwear—precisely the same market where filament rayon first rose to real volume distribution, and, in fact, the very field which constitutes the principal market for filament rayon today. Women's underwear is an entirely different matter. Except for the use of spun rayon in the knit-underwear trade, this field seems to hold little promise for spun rayon.

Turning to men's wear it appears that spun rayon has an opportunity to do a job in this field where, except for neckwear and linings, filament rayon has consistently failed to gain a foothold in the past. This may be in consequence of the fact that men's wear has for many years resisted attempts to change its design, partly, of course, because of the inherent conservatism of men in regard to dress, but also because the lines along which change should occur had not yet been indicated. But, now, some men's apparel is being functionalized along two lines: The adaptation of women's style trends to men's wear, as in beach apparel; and the conversion of men's work clothes into leisure-time apparel, a mass movement which has had its principal expression up to the present time in cotton semidress slacks. Thus another field is being prepared for spun rayon.

What the opportunities for spun rayon are in the household and industrial fields are uncertain as yet. So far they seem rather limited, although spun-rayon blankets, as an example of use in the household field, have already been successfully produced and distributed. But on the whole the strength and price requirements of these fields seem to indicate that cotton will retain its dominant position here for a long time to come. In fact it is a distinct possibility that ten years or so from now the apparel fields will be largely dominated by the synthetic fibers, while industrial and household uses will constitute the principal markets for cotton.

Poisons in Rayon Industry

PENNSYLVANIA DEPARTMENT OF LABOR AND INDUSTRY

VISCOSE-RAYON production involves certain clearly defined dangers to health which call for control by proper engineering practice, according to a report just released by the Pennsylvania Department of Labor and Industry as a result of a survey of carbon-disulphide and hydrogen-sulphide hazards in the viscose-rayon industry in conjunction with the Division of Labor Standards of the U. S. Department of Labor and the School of Medicine of the University of Pennsylvania. So far, however, it has not been possible to eliminate these dangers completely even with the best efforts of engineers.

The making of rayon by the viscose process is an important branch of manufacture in almost every industrial country; and in the United States it has grown rapidly during the last thirty years and now employs over 50,000 men and women in some twenty factories in thirteen states. The industry utilizes one poisonous substance, carbon disulphide, essential to the formation of cellulose xanthate which is an intermediate step in the production of pure cellulose, and a second poison, hydrogen sulphide, is formed during the spinning process.

The presence of these gases in excessive amounts in the breathing zone of the worker may generally be attributed to the

following causes: Failure to install churns in superimposed position over viscose mixers, inadequate inclosure of churnroom operations, leakage of gas from joints and gears in the churnroom, and inefficiency of mechanical-exhaust ventilation in contaminated zones in churnroom and spinning room.

The presence of these two poisonous gases brings viscose-rayon manufacture into the class of the poisonous trades and it is so regarded in all European countries, in Japan, and in a few of our states. But in the greater part of the United States these dangers are not recognized. Indeed, says the report, plant officials and physicians in public-health service and in private practice may be quite ignorant of any such hazards and unaware of what damage to health may be expected to follow work in certain departments of a viscose-rayon factory. It is strange but true that while many articles on occupational disease in connection with viscose production have been published in Germany, France, Italy, England, Holland, and Japan, nothing, according to the report, has appeared in American medical literature between the years 1905 and 1938, a period of 33 years during which viscose-rayon production was expanding greatly. Therefore, the results of the survey challenge not only the engineering profession but also the medical profession in finding ways and means of controlling and checking the hazards produced by the two poisons.

From group examinations of men on the job and not those incapacitated or hospital patients, the investigators found that industrial CS_2 poisoning leads to insanity; shaking palsy, St. Vitus' dance, and central sensory disturbances were not rare occurrences; enlargement of blind spots in the eye and loss of accommodation as well as lesions of the optic nerve due to CS_2 poisoning were confirmed; loss of hearing for high-pitched tones, CS_2 intoxication, dizziness, instability, giddiness, and a staggering gait were frequently observed; heart trouble was found in an unusually large number of viscose-rayon workers; exposure to CS_2 brings about a change in the blood and a loss of appetite; and, finally, a post-mortem examination of a viscose-rayon worker was made which showed toxic disease of the nerve cells of the brain and fatty changes in liver, kidneys, and heart as well as gastritis.

Applying Measured Daywork

N.A.C.A. BULLETIN

WHILE it is true that wage rates have become more rigid and various methods formerly used for labor cost control have been eliminated at the insistence of labor leaders in recent years, there is still a wide field for controlling the cost of labor per unit of product and the quality of the work, in spite of the more rigid cost per unit of time. One of these plans is measured daywork which consists of an hourly rate for each machine operator subject to change up or down periodically, depending on the man's performance. Only those whose performance can be definitely measured are included in such a plan, which was installed in the machine shop of William Sellers and Company, Inc., on Jan. 1, 1938, and is described by Coleman Sellers, 3rd, member A.S.M.E., and plant manager, in an article appearing in the Sept. 1, 1938, issue of the *N.A.C.A. Bulletin*, the semimonthly publication of the National Association of Cost Accountants. Excerpts from the article follow:

In December, 1936, the machine shop was running at about 50 per cent capacity when there was a sudden influx of orders. Orders for eight months' work were received in a space of about six weeks, and all of it was wanted in a hurry. Much of this work required changes in design involving drawings, patterns, and new time standards, resulting in a somewhat chaotic condition. The working force had to be built up rapidly and the only mechanics available were of a poorer type than the older men in the plant. Bonus times could not be met by the new men, and to hold them special allowances were made. Once this was done, they continued to expect the allowance, the bonus system became difficult to enforce, and the men lost confidence in it.

It was partly to overcome this condition that it was decided to introduce measured daywork. By having an entirely different system of payment, it was possible to cancel all bonus times and start with a clean sheet. Under the new plan, each man's rate consists of two parts, occupational rate and personal rate. The former is not subject to change. The latter is the only one that varies. For a skilled mechanic the occupational rate is about three quarters of the total rate.

To set up the rates at the start, a committee was appointed, consisting of the personnel manager, production manager, general shop foreman, and plant manager. For the personal rate, the department foreman was also put on the committee.

For the occupational rate, a survey was made of all the machine tools, and their relative importance was listed. The importance of the workmen themselves was disregarded completely, and only the job itself was considered. Each machine was evaluated as follows:

Lowest occupation in the shop	400
Skill required	max 400
Responsibility involved	max 100
Mentality	max 150
Physical effort	max 100
Working conditions	max 50
Total	1200

For the first factor the skill required to operate the machine was considered. This involves not only the time to learn to operate this type of machine, but also includes the background required and the years of experience which were required in that type of work. The skill for a small drill press was relatively low, while it was high for a large planer-type milling machine. The responsibility involved considers the hazard of error and its probable cost to the company. If a machine is used on pieces that cost hundreds of dollars, this rating is high. The mentality considers the brains and education of the man required for the job. The physical effort considers both the amount of effort and the frequency or continuity of that effort. Working conditions have to do with the temperature, lighting, dust conditions, safety, and use of cutting compound.

After rating each machine on these various points, numbers were assigned from 1200 down. In order to get a wage approximately the level for the vicinity, as determined by a survey, an arbitrary figure of 120 was assumed for a worker's perfect score. Seventy-five per cent of this is 90, and the occupational part of each man's rate was then figured by dividing the rating by 1200 and multiplying by 90. The other 25 per cent, or 30 points, represents a perfect personal rate, is made up as follows:

	Per cent
Productivity	35
Quality	35
Dependability	10
Versatility	20
Total	100

Each man was given a rating depending upon his record for the previous nine months. Dependability and versatility were determined by the committee in conference with the foreman of the department in which the man worked. If his total score

was 50 per cent, his personal rate was 0.50×0.30 or $0.15, which was added to the occupational rate.

It should be noted that productivity and quality are rated equally. The old system of payment made it difficult to control quality. The men were inclined to hurry through their work and try to get by with it and the pieces would go to inspection improperly made. By the time they were sent back to the department, considerable trouble was involved in getting the worker to correct them on his own time. With the new system, every error that takes over one hour to fix is recorded against the man and affects his rate for the next period. Furthermore, even if he gets paid for it, it will reflect in his productivity as well as his quality.

Learners are not eligible for the new plan until they have been with the company for two years and have settled on a machine for at least six months. Then they receive a rating which consists of a percentage of the occupational rate plus the personal rate. This percentage varies from 60 up. The personal rates are low, as the learners cannot be rated high in productivity, quality, or versatility. Starting rates for new men are set at the occupational rate plus 50 per cent of the full personal rate.

Duel With Machines

HARPERS MAGAZINE

EVER since Cain killed Abel because "the Lord had respect unto Abel and to his offering; but unto Cain and his offering he had not respect," men have been using the inventions of peaceful industry for destruction, and many times for reasons rising out of jealousy. As a result, thoughtless persons fall into the error of assuming that many of the powerful instruments of warfare were invented specifically for the use of armies. How wrong this assumption is Lord Rayleigh pointed out in his presidential address before the 1938 Cambridge (England) meeting of the British Association for the Advancement of Science with a few well-chosen examples, such as explosives, poison gas, and incendiary bombs, all of which originated quite innocently, and without military uses in mind, for entirely peaceful purposes.

A modern version of the Cain and Abel story, which, fortunately, ended in a draw, is told by Wessel Smitter in the October *Harpers*. It concerns two operators in a forge shop, Russ, who handled the manipulator with such uncanny skill that the big shots and visitors used to come in to watch him, and Herman, who was at the controls of the crane, and annoyed Russ by squirting tobacco juice on his machine and carrying loads too close to him for safety. One day they staged a duel. Russ used the manipulator and Herman the crane hook, and just as Russ was about to find his manipulator overturned and himself dumped out of it, someone pulled the main switch and no one was killed. (Too bad some one can't pull a switch when war starts!) It's a grand story.

Training of Engineers

THE INSTITUTION OF MECHANICAL ENGINEERS (GREAT BRITAIN)

IN THE presidential address to The Institution of Mechanical Engineers (Great Britain), delivered on Oct. 21, 1938, David E. Roberts has some things to say about the training of engineers from which the following passages are quoted:

"I do not pretend to any special knowledge on this subject, but would like to say something about the experience of some prominent steel manufacturers on the Continent, with whom I am acquainted. They have a large undertaking with several steelworks and altogether about 40,000 hands are employed. They have maintained for many years a fine educational establishment for their young men, which costs them some thousands of pounds annually. Whenever I visited them I always made a point of inspecting this interesting institution. At my last visit, about two years ago, I heard rumors that the owners were considering its abandonment, as the results had been disappointing. They had found that the men holding the important administrative positions in the works had shown no promise at all in the school, whereas nearly all those who had been brilliant in the school were holding only minor posts. The view was expressed that the latter, after being keyed up to take with credit their examinations and degrees, somehow ceased to develop thereafter. It was concluded that the best men developed late, were dull at school, and could not be regarded as worth the cost of intensive "cramming;" thus they escaped this paralyzing period without injury. The owners are now completely altering their plans and I trust at an early date to be able to see, and one day to report, as to the nature of the new method of training.

"I have been carefully studying the views expressed upon this subject of training in an interesting statement by one of our past-presidents, and the equally interesting and comprehensive reply that it provoked from one of our vice-presidents. I see much worthy of study in both. I think the view of each of us on this question is governed by his individual conception of what the human mind really is. A famous author has said that the mind may be likened to a cup into which knowledge is poured until it gradually fills. Such a conception seems to fit the cramming system of training. On the other hand, if the mind is regarded as something much more complex that only thrives upon what it absorbs by its own exertion and in its own time, then we can readily see that any kind of cramming may do great harm to a mentality not yet ripe for absorption.

"It would seem that all that educationalists can do is to lay all the jewels of their own superior knowledge before the student, so that when his spirit moves—in other words, when his mind is ripe for them—he will gather them up. I also firmly believe that when this moment does arrive, he will acquire knowledge at great speed. Such a system may not be a great success as a means of passing examinations and taking degrees, but it will produce good, sound men. I am satisfied that the only knowledge that is thoroughly absorbed is that which has been obtained by the student's own hard struggle.

"In the old days no one was regarded as an engineer at all unless he had spent some years of his life in the shops. It is obvious that this thorough grounding is not available to all young men today. Our colleges and schools provide excellent facilities and opportunities for the most enlightened education, but one feels that the rough-and-tumble treatment of the old system did inculcate something which later developed into the sturdy common sense and good judgment that fitted the engineer for management. Those early years in the shops were pretty strenuous, but they trained the use of the normal faculties of observation and the ability to make rapid decisions and to know how to act in emergencies; moreover, they imparted the invaluable experience of constant contact with the workmen.

"In the vice-president's comprehensive reply to which I referred, a committee is suggested for the selection of the most promising candidates. Such a suggestion is, in my opinion, most important and a very strong point in his scheme. Correct, farseeing selection of young men of any age is a matter of ex-

treme difficulty; a qualification very few people, influential or otherwise, seem to possess. Carnegie had a flair for this sort of thing. He attributed his great success largely to this peculiar faculty of his. I once heard him say that he had never made a choice which he regretted, and he had about forty large undertakings under his control, for all of which he had to select suitable administrators.

"A society with which I am concerned dispenses scholarships to engineering students. Over a long period of years, with one or two brilliant exceptions, the general results have been a little disappointing. Of late years, however, a new plan has been adopted. In addition to those who obtain the best examination results, others also who have obtained only moderate marks are brought before a committee of practical men. Quite often some of those highly placed by examination are passed over in favor of those with lower marks. An attempt is made in a simple practical way to estimate the *character* of the man as well as his ability. This new system has given more satisfactory results, and we feel now that these scholarships are being used to better advantage than formerly."

World's Natural Resources

SCIENCE

THANKS largely to science and technology, according to Frank E. Lathe, of the National Research Council, Ottawa, Canada, in a paper presented June 27, 1938, before the American Association for the Advancement of Science, in the series on Science and Society (see MECHANICAL ENGINEERING, February, 1938, pages 156–158), food supplies are likely to be adequate for a world population at least three or four times that of today, provided, of course, that the problem of distribution can be solved. Although the future of some of the base metals is obscure, he asserted, the world as a whole need fear no shortage for an indefinite period of raw materials for clothing, shelter, heat, power, and the principal necessities and luxuries of life. In the case of certain natural resources that are definitely exhaustible, he continued, nature has made abundant provision of possible substitutes.

In a series of tables which are here reproduced, estimates of the world's fundamental resources are presented (Tables 1, 2, and 3) and also estimates of the world's forest resources and coal reserves (Tables 4 and 5).

Coming to the subject of distribution, the speaker called attention to the fact that, unfortunately, the world is made up of a large number of economic units, many of which are endeavoring to establish economic self-sufficiency. In order to illustrate the extreme mutual dependence of the nations, he presented Table 6, in which the number "1" is taken to represent substantially complete self-sufficiency, "2" partial or temporary self-sufficiency, and "3" definite lack of self-sufficiency.

TABLE 1 ESTIMATED COMPOSITION OF THE EARTH'S CRUST

Metals	Per cent		Per cent	Nonmetals	Per cent
Aluminum	7.96	Nickel	0.023	Oxygen	47.77
Iron	4.44	Strontium	0.02	Silicon	27.25
Calcium	3.51	Chromium	0.01	Hydrogen	0.22
Potassium	2.48	Copper	0.0075	Carbon	0.19
Sodium	2.47	Zinc	0.0040	Phosphorus	0.10
Magnesium	2.28	Lead	0.0020	Sulphur	0.10
Titanium	0.47	Silver	0.00001	Fluorine	0.10
Manganese	0.09	Gold	0.0000005	Chlorine	0.01
Barium	0.08	Others	0.20	Others	0.21
			24.05		75.95

TABLE 2 ELEMENTAL RESERVES IN THE OCEAN

	Tons per cubic mile
Chlorine	90,000,000
Sodium	53,000,000
Magnesium	5,700,000
Sulphur	4,300,000
Potassium	3,300,000
Calcium	2,400,000
Bromine	310,000
Iodine	200

TABLE 3 GASEOUS RESERVES IN THE ATMOSPHERE

	Percentage by weight	Tons per square mile at sea level
Nitrogen	75.474	22,269,000
Oxygen	23.200	6,845,400
Argon	1.283	378,600
Carbon dioxide	0.040	11,800
Neon	0.00125	370
Hydrogen	0.00070	207
Krypton	0.00029	86
Helium	0.00007	20
Xenon	0.00004	12

TABLE 4 WORLD'S FOREST RESOURCES

	Percentage of the world's forest area
U.S.S.R.	21.1
British Empire (40 per cent Canadian)	21.0
Brazil	13.4
United States	9.1
France and dependencies	3.9
Argentina	3.5
Japan	1.2
Germany and Austria	0.5
Italy and Abyssinia	0.4

TABLE 5 COAL RESERVES OF THE WORLD

	Millions of metric tons
United States	3,838,657
British Empire	1,729,105
China	995,587
Germany and Austria (1913)	477,232
U.S.S.R.	173,879
France and dependencies	37,585
Japan	7,970
Italy	243
World total	7,397,553

TABLE 6 NATIONAL SELF-SUFFICIENCY IN MAJOR MINERALS

	Br. Emp.	U.S.A.	U.S.S.R.	France and dep.	Germany	Italy	Japan
Coal	1[a]	1	1	1	1	2	2
Iron	1	1	1	1	2	3	3
Copper	1	1	2	3	3	3	2
Lead	1	1	3	3	1	2	3
Zinc	1	1	2	2	2	3	2
Nickel	1	3	3	2	3	3	3
Tin	2	3	3	3	3	3	3
Asbestos	1	3	1	3	3	3	3
Petroleum	3	1	1	3	3	3	3

[a] Numerical order represents decreasing abundance in relation to national requirements.

From Table 6, he said, it is evident that not a single one of the seven great powers is completely self-sufficient in supplies of the major minerals, although the British Empire and the United States are in the happiest position in this respect. In his opinion the U.S.S.R. is in a better relative position than that indicated by the table, since so large a part of her vast area is virtually unprospected. The other nations, he stated, are very dependent upon international trade in minerals.

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

Oxyacetylene Surface Hardening

To the Editor:

The author has presented an exceedingly instructive paper[1] and, with few exceptions, the writer is strictly in accord with his views.

There is no question that good results can be obtained by manual means, but greater uniformity can be insured by eliminating the human element, particularly in the rate of flame speed and maintenance of the proper distance from the torch to the part to be hardened. Proper settings of any machine will, however, depend to a large extent upon the judgment and experience of the operator.

It is possible perhaps to eliminate stress relieving on helical gears with wide faces where the unit stresses are usually low and the load is not applied along the full-tooth length at the same instant. However, spur gears, particularly those with small teeth, should be drawn if it is at all feasible to do so. It is entirely possible that the change of structure and hardness may extend down into the tooth fillet. This condition, together with the fact that heavier tooth loads may be encountered, increases the danger of fatigue cracks originating at this point.

Leo M. Martin.[2]

To the Editor:

The author calls attention to the advantage of using this process in conjunction with the hardening of carburized parts, and while it is ideal for this application from a standpoint of straightening and distortion, there still exist several pertinent factors which cannot be overlooked.

In the carburizing process the parts have a surface of high carbon content, usually between 0.90 and 1.10 per cent carbon. To harden this material properly involves considerable skill if checking and a flow of the surface metal during the hardening operation and spalling of the case while in service are to be avoided.

These difficulties may be partially overcome by diffusing the carbon in the case prior to flame hardening. However, the most successful procedure has been found to be imparting a case lower in carbon, usually between 0.60 and 0.70 per cent. With this carbon content, the material can be hardened readily.

Another factor worthy of mention is the substitution of materials when changing to the torch-hardening process. Too much attention appears to be focused on surface hardness and not enough on core strength and structure. If the file touches the surface the inspection department issues a complaint, but in rare instances is a reference made to the condition of the core. Many are of the opinion that they can use any type of material which will produce the required surface hardness. They will not go to either the trouble or expense of normalizing or heat-treating the core prior to torch hardening, but insist upon using the parts in the as-forged or as-cast state.

In many instances parts possessing high physical properties and a well-refined core have been replaced with parts of low physical strength and a coarse and weak core structure.

Substitutions of this nature usually result in premature failure and condemnation of the process. Where flame-hardened parts are substituted for untreated material, there is little danger of going wrong; but where substitutions for heat-treated sections are contemplated, it is important that the core properties of the flame-hardened sections equal those of the heat-treated parts, unless the heat-treated component was treated for surface hardness only and strength is not a vital factor.

R. L. Rolf.[3]

To the Editor:

The author is in entire agreement with Mr. Martin's opinion that flame-hardening development should be in the direction of mechanical methods which will eliminate the human variable. Good results may be obtained manually and not infrequently it is uneconomical to make a mechanical setup.

The point is well made that gear teeth, particularly small teeth, be stress-relieved. In time to come data will be developed which will indicate the need for stress relief on the basis of loading. In the meantime, the only safe recommendation is a stress-relieving treatment.

The writer is pleased to receive Mr. Rolf's comments on experience in flame hardening carburized materials. Unfortunately, sufficient data have not been developed on this phase of the process to allow one to arrive at definite conclusions or make specific recommendations.

The suggestion that attention be directed to core properties as well as surface hardness can hardly be overemphasized. It is only through a careful consideration of both core and case properties that the greatest advantages of flame hardening may be realized.

A. K. Seemann.[4]

Boiler Operation as It Affects Prime Movers

To the Editor:

The author of this paper[5] draws some interesting conclusions both as to the measurement of the amounts of carry-over in the steam and the cause of turbine-blade deposits.

In referring to the effect of alkalinity on steam quality, the author states "it will be noted that the curve in Fig. 3 changes slope when the alkalinity is approximately 17 per cent of the total solids . . . ." In the figure quoted, alkalinity is reported as NaOH. In the text, however, alkalinity is not referred to as NaOH. It would be interesting to know whether the author means total alkalinity, arrived at by a methyl-orange titration, calculated to NaOH, or whether he refers to actual sodium hydroxide present, and if the latter, what method of determination was used.

The author in speaking of the method

[1] "Oxyacetylene Surface Hardening," by A. K. Seemann, Mechanical Engineering, July, 1938, pp. 535–540.

[2] Pacific Gear & Tool Works, Inc., San Francisco, Calif.

[3] Lakeside Steel Improvement Company, Cleveland, Ohio.

[4] Engineer, Linde Air Products Company, New York, N. Y.

[5] "Boiler Operation as It Affects Prime Movers," by S. E. Tray, Mechanical Engineering, June, 1938, pp. 475–480.

used in measuring the impurities of steam, through the use of a recording ammeter, states that such apparatus is only relatively correct and the question arises whether "relatively correct" is of sufficient accuracy upon which to draw conclusions. He also states that no corrections were made for the presence of dissolved gases, but that "the quantity of dissolved gases present in steam is reasonably constant with a given water condition." The writer's experience has been entirely opposite from this, especially in plants operating under conditions requiring a high percentage of make-up water. The addition of feedwater to a boiler is seldom at a constant rate and at times, when larger quantities of raw water are introduced, increasing quantities of carbon dioxide will be present only to be released with the steam. The condensation of the steam for sampling under boiler pressure, tending to put these gases into solution, will only increase the inaccuracy due to their presence. Both carbon dioxide and ammonia affect conductivity to a large extent. Powell[6] and others show that 1 ppm free carbon dioxide accounts for 1.667 micromhos specific conductance. Preliminary work which has been conducted in our laboratory shows that 1 ppm ammonia (NH_3) will give a specific conductance of approximately 3 micromhos, at 80 F. This latter is equivalent to approximately 1.6 ppm sodium sulphate, 0.5 ppm sodium hydroxide, or 2.1 ppm sodium bicarbonate. This points to the necessity of the elimination of dissolved gases, particularly carbon dioxide and ammonia, if accurate results are to be procured by the electric-conductivity method of measurement.

It is noted that the author makes no mention of any correction for temperature variations. It is well known that temperatures play an important part in specific-conductance determinations, and unless steps are taken to provide for a uniform temperature of the condensate, at the point of cell immersion, inaccuracies and fluctuations will ensue.

It is also stated that the electrodes used in the apparatus described were made of stainless steel. Electrodes of this material would undoubtedly be subject to polarization. Powell[6] also points out the fact that polarization is one of the most important points of inherent errors in conductivity measurement and recommends the use of platinized platinum electrodes to overcome this deficiency.

The author's conclusion regarding the part played by silica in turbine-blade deposits is indeed interesting.

In concluding his article, he states "if this brief consideration of the factors affecting prime movers will promote further investigation of this important problem, then its purpose will have been amply fulfilled." It is with this idea in mind that the writer submits these suggestions for his consideration.

L. DREW BETZ.[7]

TO THE EDITOR:

The advent of higher steam pressures has not only increased the importance of chemical control of feedwater but it has rendered the problem more difficult. The increase in pressure has necessitated thicker boiler drums with consequent limitation in size and steam-liberating surface, while at the same time it has aggravated the problem of separating steam from water, due to the increase in steam density. The high-temperature feedwater entering the boiler from the economizer complicates the problem of steam washing so that limits are being approached in several directions. Combined with these limitations, the higher temperature has decreased the solubility of the usual salts in the boiler water and necessitated lower concentrations. With fairly low concentration limits the effect of the introduction of additional solids for treatment must be carefully weighed. Theoretically, the treatment which introduces the smallest amount of solids into the boiler appears most attractive, other things being equal, but there are other influences to consider.

Mr. Tray's paper presents some interesting experiences in boiler-water treatment and a unique method for combating turbine-scale deposits. It is realized that water conditions vary greatly in different plants and there is no universal remedy to meet all situations. One of the problems of plants located on the seaboard is the introduction of sea water into the boilers, due to unavoidable condenser leakage. The variable nature of this leakage injects uncertainties into the problem so there is no simple means of accurately determining the scale-forming solids which are entering the system through this source. With adequate maintenance methods this leakage may be maintained at a low figure but, due to the high concentration of solids in the sea water, the amount of salts entering the system may be relatively large. Determination of the chloride content and also the use of conductivity meters afford simple means for approximating leakage, but the ratio of scale-forming to total solids varies with changes in tides, as well as seasons, so that treating methods must be adequate to meet these conditions. In the high-pressure plant at Waterside Station about 3 ppm of disodium phosphate is being used, together with sufficient caustic soda, to combat the hardness resulting from condenser leakage. While this leakage is exceedingly low it is carefully watched and proper precautions are observed to safeguard the boilers.

Under such variable hardness conditions the presence of an excess of phosphate and alkalinity within the boiler affords protection against scale formation and eliminates the necessity of close coordination between feedwater changes and treatment. While this method adds to the total solids and perhaps impairs the boiling characteristics of the water, it does simplify the technique of treatment. In the interest of economy in power production, operating simplicity is desirable, and it is important initially to select equipment which is not unduly sensitive to water conditions. While the problems become more difficult with increasing pressures there are often alternatives for solving them when their seriousness is sufficient to justify a change in procedure.

The nature of the load on the main unit is usually an influence in the formation of turbine-blade scale. A fixed load is favorable to scale accumulation, but with variable load the saturation zone shifts over a considerable range in the turbine and retards scale formation. There are some peculiarities about the formation of insoluble blade scale for which there is no simple explanation, but much progress has been made in determining their causes. Plants and marine installations which operate with sea-water contamination seldom develop insoluble blade-scale problems, and while there are exceptions, it seems likely that the character of the make-up water may account for some of the exceptions.

The control of blowdown is an important problem, but the general practice, while usually based on sound experience, is comparatively crude. One plant may find that an increase in boiler concentration from 1200 to 1500 ppm necessitates doubling the frequency of turbine-blade washing, while other plants with similar equipment may find a much lower or higher equilibrium point. It appears in some instances the problem is more physical than chemical and substantial improvements may occasionally be made by

[6] "Developments of Apparatus for Measurement of Steam Quality by Electrical Conductivity Methods," by S. T. Powell, H. E. Bacon, Jr., I. G. McChesney, and F. Henry. Paper presented at 29th Annual Meeting of the American Institute of Chemical Engineers, Baltimore, Md., Nov. 11–13, 1936.

[7] General Manager, W. H. & L. B. Betz, Philadelphia, Pa. Mem. A.S.M.E.

lowering the water level. It is likely that in some cases the use of a skimmer or surface blowdown might be advantageous. Many of the smaller plants operate without the technical skill found in the larger ones and the writer recalls one mill plant where about the only indication available for scheduling blowing down was the audible squeaking of the engine valves, due to carry-over.

A number of years ago carry-over troubles in one plant aroused interest in determining the concentration limit for a certain type of boiler. Centrifugal separators were installed inside the boiler drum on the saturated-steam nozzles through which steam passed to the superheater. The drains from these steam purifiers or moisture separators were taken to an external steam trap. The boiler was operated over a year without any blowdown other than the periodic water-column tests and using the ordinary phosphate treatment. At low rating on the boiler the concentration would run up to around 3000 ppm or higher, while with high ratings it would diminish to around 2000 ppm. The variation in the amount of suspended solids did not appear to follow a fixed rule. This experience seemed to indicate attractive possibilities for this type of concentration control for moderate-pressure boilers except for the problem of trap maintenance. The moisture discharged with the steam took the place of the usual blowdown, or in other words, the boiler primed itself into equilibrium as regards concentration. The possibility of heavy carry-over with rapid increase in rating caused some concern, but no trouble was experienced and steam quality was adequate.

Turbine-blade scale is not always due to steam from the boiler; instances have been reported in which it was attributed to carry-over from an interstage evaporator and in another case it was attributed to leakage of a surface-type desuperheater on temperature control. While turbine-blade scale is a problem in some plants, it is seldom a major one; in fact, in many instances it is secondary to the problem of boiler sludge and scale, especially where the boiler circulation is not entirely adequate. With improper circulation, treatment is difficult and sludge accumulations in starved tubes constitute a problem. Troublesome scales occasionally develop from unexpected sources; for example, the iron oxide which accumulated in feed lines and economizers during the stand-by period produced an acute scale condition in one boiler plant. The high iron content and the tenacious nature of the scale rendered it practically impossible to remove with the turbine cleaner. It was the general opinion that this scale resulted from deficient alkalinity.

While silica has been a troublesome constituent in numerous plants, it appears to follow no well-defined rule. Information on the silica-content range in waters likely to cause trouble would be welcome. Turbine-blade scale which may be readily washed off by the use of saturated steam is of little concern. Insoluble blade scale constitutes a real problem in some plants and is worthy of the attention it is receiving.

The conductivity meter used by the author is a simple and dependable piece of apparatus when properly used. The writer has employed this type of instrument in some plants for many years for indicating condenser leakage. While the conductivity method of measuring concentration is sensitive to temperature of the sample this may be compensated for by the use of a table or by adjustability in the conductivity cell.

In spite of some troubles in conditioning water for it, the thermosiphon-circulation boiler is generally a dependable piece of apparatus. In this connection it might be mentioned that some of the European high-pressure boiler installations, claiming advantages in the use of raw water, are now operating on straight condensate.

The author is to be commended on the able presentation of this important subject.

W. E. CALDWELL.[8]

TO THE EDITOR:

In reviewing the June issue of MECHANICAL ENGINEERING, it would not be amiss to compliment Mr. Tray on his article, "Boiler Operation as It Affects Prime Movers."

The writer notes with especial interest that the distinction between priming and foaming has been definitely pointed out. He has endeavored to do this same thing in other engineering journals, and feels that the more publicity given toward correcting these terms generally so loosely used, the better. As Mr. Tray points out, priming is usually the mechanical lifting of varied amounts of boiler water into the steam flow; while foaming is the transmission of steam encased in a film of boiler water in the form of bubbles usually having a high surface tension.

It is thought that Mr. Tray should have elaborated on the term "carry-over" in his defining paragraphs under the subtitle "Priming, Foaming, and Carry-over." It seems that in many parts of this country the word carry-over is used quite correctly in either the form of a verb or a noun. While it may have been rather vague in past years to apply this word in both cases, it seems well understood now that carry-over as a verb applies to the act of transmitting any substance foreign to normal steam conditions from the boiler and entrained in the flow of saturated steam.

On the other hand, carry-over as a noun is commonly and probably properly used to denote the foreign properties in the vehicle of steam flow. This, therefore, may be applied to denote moisture, suspended solids, or any other foreign matter.

HARRY M. SPRING.[9]

TO THE EDITOR:

In his discussion Mr. Betz has asked the meaning of the term alkalinity, as used in the curves of Figs. 2 and 3. This is the actual sodium-hydroxide alkalinity determined by acid titration following the precipitation of carbonates with barium chloride. The caustic alkalinity appears to be of more importance than the total alkalinity, as has been demonstrated in certain plants where a supplementary acid treatment reduces the caustic alkalinity to about half the total alkalinity, and where similar results in regard to the prevention of carry-over have been obtained.

The remarks of Mr. Betz concerning the method of measuring impurities in steam are correct as applied to methods developed by Powell, Rummel, Hecht and McKinney, and others. He has apparently overlooked the fact that the purpose of this instrument is not to obtain absolute measurement of steam conditions but only to compare conditions continuously from one time interval to the next. The effect of dissolved gases on conductivity is much less than that of boiler-water salts particularly when any appreciable carry-over is present. It will be obvious that the temperature of the sample will be constant as long as the flow of steam and water to the condenser remains uniform. Since all measurements are taken at the same temperature, no corrections are necessary. The effect of polarization on the electrodes appears slight when using alternating current, as the case with this instrument. Its use in many plants over a three-year period has ably demonstrated its effectiveness for the purpose for which it has been used.

Mr. Caldwell's remarks concerning op-

[8] Mechanical Plant Engineer, Consolidated Edison Company of New York, Inc. Mem. A.S.M.E. and Melville Medalist.

[9] Mutual Boiler Insurance Co., Canton, Mass. Jun. A.S.M.E.

eration of boilers at higher pressures and temperatures are interesting in view of the considerable experience which he has had in this field. It is realized, of course, that the condenser-leakage problem of plants located on seaboard is considerably different than those located inland. Generally speaking, however, in the case of seaboard plants, condenser leakage tends to introduce principally soluble salts into the feedwater system. In the case of plants located inland, however, condenser leakage may introduce, in addition to scale-forming salts, considerable suspended matter and organic matter as well. The fact brought out by Mr. Caldwell that plants operating with seaboard-water contamination seldom develop insoluble turbine-blade deposits is extremely interesting. It may be possible to account for this due to the fact that sea water contains a high percentage of magnesium salts which will be available to effect a precipitation of silica in the boiler water, thus reducing the soluble-silica content. It is quite true that the nature of the load on the turbine has an appreciable influence on the formation of turbine-blade deposits. In the case of plants experiencing frequent shutdowns, as for example, over every weekend, it is seldom that there is any difficulty from accumulation of deposits. As a matter of fact, some plants find this shutdown method suitable for the removal of soluble deposits on the turbine blading.

Mr. Caldwell has raised the point that the problem of boiler sludge and scale in high-pressure plants may be even more important than turbine-blade deposits. It may be true that boiler circulation is responsible to some extent for some of these deposits in boiler tubes. On the other hand, if the sludge and total solids in the boiler water are kept to a minimum with the proper treatment there is less tendency for difficulty from this source even where the boiler circulation is not entirely adequate. It will be obvious to any one in close contact with the operation of high-pressure plants that various local conditions make each plant a specific problem in itself and that there can be no universal panacea for the elimination of difficulties due to water and steam conditions. The principles outlined in the author's paper, however, have withstood the test of actual performance in the field and constitute a basis on which to progress further in the future.

Mr. Spring's remarks concerning the distinction between foaming and priming are very pertinent in view of the necessity for a more definite understanding of these terms. As Mr. Spring points out, "carry-over" as a noun is properly used to denote the foreign properties in the vehicle of steam flow. On the other hand, it is the author's thought that "carry-over" used as a verb applies to the action of transmitting foreign substances with the steam in a rather constant amount. In other words, while foaming and priming may occur spasmodically, there are some plants which operate continuously with small amounts of moisture and suspended solids and it is to these that the term "carry-over" is intended to apply.

S. E. TRAY.[10]

[10] Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretation of this Committee formulated at the meeting of September 16, 1938, and subsequently approved by the Council.

CASE NOS. 515, 706, 782, 819, 838, 843, 849, 852, 854, 856, 858, 862

(Annulled)

CASE NOS. 780 and 864 (Reopened)

(In the hands of the Committee)

CASE NO. 865

(Interpretation of Par. U-20)

Inquiry: May the provisions given in revised Par. P-180 be applied to Par. U-20?

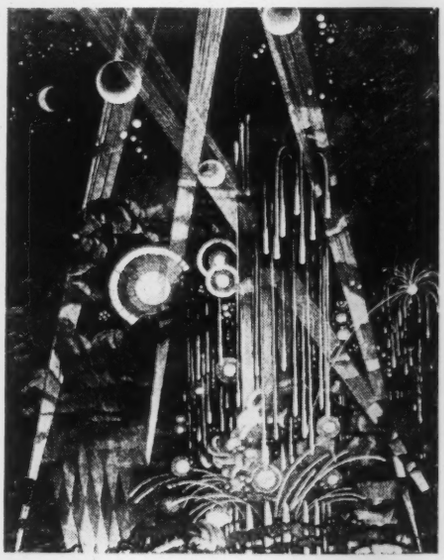
Reply: Yes, they can be so applied.

CASE NO. 866

(Interpretation of Par. P-102e)

Inquiry: All material specifications state that if the percentage of elongation of any tension test specimen is less than that specified and any part of the fracture is more than $^3/_4$ in. from the center of the gage length of the 2-in. specimen, or is outside of the middle third of the gage length of the full-size specimen as indicated by the scribe scratches marked on the specimen before testing, a retest shall be allowed. Par. P-102*e* prescribes both the transverse test and the weld metal test without the equivalent provision for retesting when the fracture is not in the proper location for taking correct measurements and readings. Is it not the intention of the Committee to allow the same retest under such conditions?

Reply: It is the opinion of the Committee that for the weld metal test sample provided in Par. P-102*e*, if the percentage of elongation of any tension test specimen is less than that required and any part of the fracture is more than $^3/_4$ in. from the center of the gage length of the 2-in. specimen, a retest shall be allowed.



ARTIST'S SKETCH OF FIREWORKS FOR WORLD'S FAIR, NEW YORK, 1939

(Trip to Fair Grounds is planned during A.S.M.E. Annual Meeting, December 5–9, 1938; see page 986.)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Citizenship

"How to Be a Responsible Citizen." By Roy A. and Eliza G. Wright. Association Press, New York, N. Y., 1938, 5⅜ × 8 in., 203 pp., $2.

Reviewed by W. H. Winterrowd[1]

THERE has never been a time in the history of this country when its citizens have needed so much as now to be awakened to the tremendous and crucial importance of responsible citizenship.

One of the chief virtues of our Federal Constitution is that it provides for a strictly representative government; but unless every citizen endeavors to exercise his guaranteed right in a responsible, wise, honest, and continuous manner, our form of government will tend to drift away from the anchor sites that have marked our welfare, stability, and strength of character.

What is responsible citizenship and how can we become responsible citizens? Roy and Eliza Wright have answered that question in a book that is teeming with inspiration and sound practical aids. Many books have been written on civics, but this book does not duplicate the material contained in them. "How to Be a Responsible Citizen" is a practical guide to responsible citizenship. It is beautifully written and says more in fewer words than most books touching upon the subject. It is a book that should be read by every member of The American Society of Mechanical Engineers. It should be read by every citizen in this country. It should be a textbook in our public schools.

In this day and age, indifference to civic responsibility has brought about a tendency to criticize our public schools for not doing what is properly a function of the home. Harry F. Atwood, in his book, "Safeguarding American Ideals," emphasizes the fact that the homes of the American people are the foundation stones on which the structure of our republic rests and that they are the fountains, the springs from whence must come the lifeblood of Americanism.

Parents have a civic as well as a moral responsibility in the home. Raising these standards will go far toward the elevation of all other ideals. "How to Be a Responsible Citizen" is a book that should find a place in every home where it should be used not only as a practical guide but as an aid to clarify thinking on civic matters and to help parents instill into their children an understanding of and high regard for their civic responsibilities.

The book is excellently prepared for perusal and reference. The first part consists of a brief but thoroughly instructive history of the growth and development of representative democracy. The second part deals with the things that a responsible citizen should do. It makes perfectly clear, even to the tyro, how to take the necessary steps to get the information needed to enable him to take an active interest in civic matters. To readers whose indifference is responsible for their feeling that such participation is difficult, this part of the book will be a revelation. The third part of the book supplies many helpful suggestions about the wealth of materials and numerous agencies from which the citizen can secure information and help. The concluding section of the book deals with the broader issues involved in citizenship in a democracy.

A review of this book would be inadequate without reference to the bibliography that it contains. The bibliography alone would make the book an outstanding work on civic matters as well as the responsibilities of a citizen.

The authors of this book need no introduction to the members of The American Society of Mechanical Engineers. Doctor Wright is a past-president of the Society and he and Mrs. Wright for many years have been active in welfare and civic affairs, both nationally and in their own home community. Mrs. Wright, a member of the Board of Recreation of East Orange, N. J., led the women of New Jersey in the Dwight W. Morrow primary campaign for United States senator and was national chairman of the Hoover-for-President Engineering Women's Division in 1928 and 1932. Doctor Wright, a well-known railroad mechanical engineer and later a nationally known editorial executive of a number of engineering publications, has served a three-year term as freeholder of Essex County, N. J., and was an officer of the Engineers' Hoover-for-President movement. He has lectured and written much on matters pertaining to good citizenship. One of his outstanding accomplishments in this connection is a course in citizenship that he has conducted for the last five years at the Newark College of Engineering, a course that is now a requirement for graduation at that college—a course that could be emulated in other schools and colleges with results of untold value.

During the past few years there has been much talk of the importance of bringing to the minds of citizens of this country a realization of the importance of responsible citizenship and its direct connection with our future welfare. Doctor and Mrs. Wright have done more than talk. They have worked actively and tirelessly for many years to bring about higher standards of citizenship and a greater realization that the future welfare of this country depends upon responsible citizenship. Their book reflects their great experience, knowledge, and fine ideals.

There is no royal road to responsible citizenship. To become a responsible citizen requires not only interest but personal activity motivated by the highest ideals, those ideals that were the wellsprings of inspiration in the hearts of our forefathers who gave us a constitution guaranteeing representative government and personal freedom. The book, "How to Be a Responsible Citizen," provides a cornerstone on which to build that type of responsible citizenship that will help us maintain the priceless institution of true representative government given to us by our forefathers, a government that today needs responsible citizens more than at any other time in its history.

[1] Vice-president, Franklin Railway Supply Co., Inc., Chicago, Ill. Member Special Committee on Manual on Citizenship, The American Society of Mechanical Engineers.

Indicators

DER INDIKATOR. By K. J. DeJuhasz and J. Geiger. Julius Springer, Berlin, 1938. Cloth 6 × 9 in., 293 pp., 392 illus., 28.80 rm (U. S. $8.40).

REVIEWED BY THEODORE B. HETZEL[2]

ENGINE indicators are an indispensable aid in the testing of piston-type machines and engines and played an important part in the development of engines from the slow-moving and wasteful early steam engines up to high-speed and high-efficiency aero-engines of today. Although there has been in recent years a keen activity in the development of engine indicators, especially of the optical and electrical types, there has appeared no exhaustive treatise on this subject for many years, and descriptions of these instruments are widely scattered in the periodical and patent literature.

The book under review aims to supply this want. Both authors have had long experience with indicators and their familiarity with and love for this subject is evidenced throughout the book. Professor DeJuhasz was, earlier in his professional activities, chief engineer of a German indicator company, and he then developed and used high-speed indicators as research engineer on racing engines with Italian automobile companies. In his present connection with the Engineering Experiment Station of The Pennsylvania State College his experiments on fuel injection are based on a new optical indicator described in the book. Indicators are his absorbing interest; throughout his life he has either designed, used, or written about them. The coauthor, Dr. Ing. J. Geiger, is chief engineer of the Augsburg (Germany) works of the M.A.N., the cradle of the Diesel engine, to the development of which he made important contributions. He is a well-known expert on vibration problems, being the originator of the torsiograph and vibrograph which bear his name. Furthermore, he contributed to the development of indicators a mean-pressure indicator (so-called "Pimeter"), and a very sensitive optical indicator which is also described in the book. The third partner, the publishing house of Julius Springer, has made a typographically excellent book with beautifully executed drawings and diagrams on nearly every page.

In keeping with its character as a general treatise, the book includes indicators of all designs and principles. These are: Mechanically magnifying and recording indicators; optically magnifying indicators (microindicators); optically indicating or recording indicators with one mirror and with two mirrors; electrically operated indicators (resistance, piezo-electric, photoelectric, capacitance, inductance, electomagnetic), with discussion of oscillographs, cathode-ray tubes, and cathode-glow tubes; point-by-point indicators; special indicators (continuous diagrams, work, power, maximum and mean pressures, pressure differences, detonation, etc.). Chapters are included which discuss the following: Testing and calibrating indicators; diagram errors; dynamics of the indicator; mechanical versus electrical indicators; the interpretation of diagrams. All in all about one hundred and forty indicators of all types are treated in detail. The book is truly international in scope; developments and inventions originated by Americans, Germans, French, English, Dutch, Hungarian, Swiss, Italian, Russian, and Japanese engineers are included.

The well-known activity of The Pennsylvania State College in the field of fuel-injection and knock research is evidenced by the numerous instruments, described in this book, which were originated fully or partly at that institution.

Although the book is in German, those who do not read German will find the excellent drawings to be well worth the book. Each figure is fully explained in the accompanying caption; to understand the caption a dictionary may be required, but a reading knowledge of German would not be necessary. Those who wish to pursue the study further will welcome the guidance of the bibliography of over two hundred and fifty titles (nearly one half of which refer to books and articles in English). A commendable feature of the bibliography is that many of the titles are followed by brief résumés of the contents.

The book covers its subject up to the present day, and unless the future development of indicators is to be unexpectedly rapid, it should fill its purpose for many years to come. All engineers and research workers who have occasion to measure pressure variations or small motions of high frequency will profit by a study of the detailed discussions presented here of the solutions found by other workers and of the various types of indicators available on the market.

[2] Engineering Department, Haverford College, Haverford, Pa. Mem. A. S.M.E.

Books Received in Library

ATM—Archiv für Technisches Messen. Lieferungen 85–87, July–Sept., 1938. R. Oldenbourg, Munich and Berlin, Paper, 8 × 12 in., illus., diagrams, charts, tables, 1.50 rm. each. Three numbers of a monthly publication containing classified articles upon various types of apparatus and methods for technical measurements. Certain numbers also contain descriptions of specific instruments manufactured by German companies.

AIR CONDITIONING FOR COMFORT. By S. R. Lewis. Third edition. Keeney Publishing Co., Chicago, 1938. Cloth, 6 × 9 in., 285 pp., diagrams, charts, tables, $2.50. A general treatment of the field, covering thermodynamical and physical fundamentals, heat transmission, heating and air-conditioning systems, refrigeration systems and refrigerants, air distribution, and noise control. A final brief chapter includes certain codes and regulations.

COMBUSTION, FLAMES, AND EXPLOSIONS OF GASES. By B. Lewis and G. von Elbe. University Press, Cambridge, England; Macmillan Co., New York, 1938. Cloth, 6 × 9 in., 415 pp., illus., diagrams, charts, tables, $5.50. A coordinating and critical appraisal of the literature concerning the numerous investigations in combustion phenomena of recent years. The material is considered under four main headings: Chemistry and kinetics of the reactions between fuel gases and oxygen; propagation of flames; state of the burnt gas; problems in technical combustion processes. Various thermochemical and other tables and diagrams are appended.

DIESEL ENGINEERING. By J. W. Anderson. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 9 in., 269 pp., illus., diagrams, charts, tables, $3. This college textbook on the fundamentals of the subject emphasizes the theory and principles of thermodynamics, combustion, mechanics of engine design, and installation principles. Such subjects as governing, cooling, and lubrication are also considered.

ECONOMICS FOR ENGINEERS. By E. L. Bowers and R. H. Rowntree. Second edition. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 9 in., 591 pp., diagrams, charts, tables, $4. This is a practical presentation of economic principles for engineers and engineering students, in which the subject is treated as concisely as possible and the engineering aspects of economic theory and business activity are emphasized. This new edition has been entirely rewritten and several chapters have been added.

DIE FEDERN, ihre Gestaltung und Berechnung. By S. Gross and E. Lehr, edited by P. Speer. V.D.I. Verlag, Berlin, 1938. Cloth, 8 × 12 in., 136 pp., illus., diagrams, charts, tables, 25 rm. This volume, prepared under the auspices of the subcommittee on Spring Design of the Verein deutscher Ingenieure, aims to discuss the whole field of spring design in a uniform manner and from a practical point of view. Leaf, cylindrical, helical, ring, and other springs are considered, covering all types used in vehicles and machinery.

FORMULAS FOR STRESS AND STRAIN. By R. J. Roark. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 9 in., 326 pp., diagrams, tables, $3. The book brings together the formulas, facts, and principles per-

taining to the strength of materials which are required in the more precise and accurate methods of stress analysis imposed by modern engineering trends. Part one contains definitions of terms. Part two discusses general principles, methods of stress analysis, and the behavior of material under stress. Part three discusses the behavior of structural elements under various conditions of loading and gives extensive tables of formulas for the calculation of stress, strain, and strength. Numerous lists of references are included. The volume should be a useful reference book for the designing engineer.

GETTING A JOB IN AVIATION. By C. Norcross. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 8 in., 374 pp., illus., $2.50. Designed for young men in search of a vocation, this book describes the kinds of jobs available in aviation and the ways to get them. What workers do, their pay and working conditions, the requirements and opportunities are explained. Advice is given concerning training and its cost, and the future of the industry is considered.

Great Britain, Air Ministry, Aeronautical Research Committee Reports, and Memoranda:

No. 1798. GALERKIN'S METHOD IN MECHANICS AND DIFFERENTIAL EQUATIONS, by W. J. Duncan. 33 pp., $1.40.

No. 1803. VISUAL AND PHOTOGRAPHIC METHODS OF STUDYING BOUNDARY LAYER FLOW, by H. C. H. Townsend. 22 pp., $1.65.

No. 1808. DETERMINATION OF DRAG BY THE PITOT TRAVERSE METHOD, by G. I. Taylor. 10 pp., $0.50.

No. 1814. WIND TUNNEL TESTS AND CHARTS OF AIRSCREWS AT NEGATIVE THRUST, by C. N. H. Lock, H. Bateman, and H. L. Nixon. 20 pp., $0.95.

No. 1818. AN APPROXIMATE METHOD OF STRESSING THE STRUTS OF A STIFF-JOINTED FRAMEWORK, by J. B. B. Owen and J. Taylor. 30 pp., $1.25.

No. 1819. FULL-SCALE TESTS OF SLOTTED FLAPS AND AILERONS ON A COURIER, by R. H. Francis, 20 pp., $0.95.

No. 1821. A REVIEW OF SOME FULL-SCALE TESTS ON LANDING FLAPS, by J. E. Serby. 17 pp., $0.80.

No. 1823. GUST LOADS ON TAILS AND WINGS, by D. Williams and J. Hanson. 39 pp., $1.65.

No. 1824. RELAXATION METHODS APPLIED TO GRID FRAMEWORKS, by D. G. Christopherson. 12 pp., $0.65.

No. 1828. ABSTRACTS OF PAPERS PUBLISHED EXTERNALLY. 20 pp., $0.95.

His Majesty's Stationery Office, London, 1937. (Obtainable from British Library of Information, 270 Madison Ave., New York.) Paper, 9 × 12 in., illus., diagrams, charts, tables. Reports on various technical problems, experimental work and mathematical computations concerned with or of interest in aeronautical and aerodynamical design. Number 1828 contains abstracts of all papers recommended for external publication after April 1, 1932, and not included in the Reports and Memoranda Series.

Great Britain. Scientific and Industrial Research Dept. FOREST PRODUCTS RESEARCH BOARD Report 1937. His Majesty's Stationery Office, London, 1938. Paper, 6 × 10 in., 87 pp., illus., diagrams, charts, tables. (Obtainable from British Library of Information, 270 Madison Ave., New York, $0.65.) Contains general information concerning the organization, staff, work, and publications. There are also brief descriptions of the many research problems under investigation and of the kinds of specific inquiries dealt with.

Great Britain. Scientific and Industrial Research. FUEL RESEARCH Technical Paper No. 47, THE PRODUCTION OF ACTIVE CARBON FROM BITUMINOUS COAL. His Majesty's Stationery Office, London, 1938. Paper, 6 × 10 in., 55 pp., illus., diagrams, charts, tables. (Obtainable from British Library of Information, 270 Madison Ave., New York, $0.40.) A report on the production from lump coal of an active carbon which is suitable for use in gas respirators. Discusses the choice of coal, the laboratory method, the transfer of the process to semitechnical and full-technical scale, and the application of carbons to industrial processes.

GRUNDBEGRIFFE UND HAUPTSÄTZE DER HÖHEREN MATHEMATIK. By G. Kowalewski. Walter de Gruyter & Co., Berlin, 1938. Cloth, 6 × 9 in., 156 pp., diagrams, tables, 5 rm. A concise presentation of the fundamentals of higher mathematics, with special attention to the needs of engineers and physicists, by an experienced teacher.

DIE GRUNDLAGEN DER RAUMKÜHLUNG. By W. Tamm. J. Springer, Berlin, 1938. Paper, 6 × 10 in., 80 pp., diagrams, charts, tables, 9.60 rm. This pamphlet on the fundamentals of room refrigeration is chiefly devoted to the thermodynamical considerations underlying the three major phases of the subject: Temperature control, relative humidity, and the state of motion of the air in the room. Two large heat-content-concentration diagrams for moist air over different temperature ranges are included.

INTRODUCTION TO INDUSTRIAL MANAGEMENT. By F. E. Folts. Second edition. McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 9 in., 566 pp., diagrams, charts, tables, $4. A presentation of the essentials of industrial management by means of actual cases exemplifying major management topics, followed by discussion of the principles involved. Each topic is accompanied by from one to four problems which necessitate the application of these principles. The intention has been to emphasize the business aspects of management.

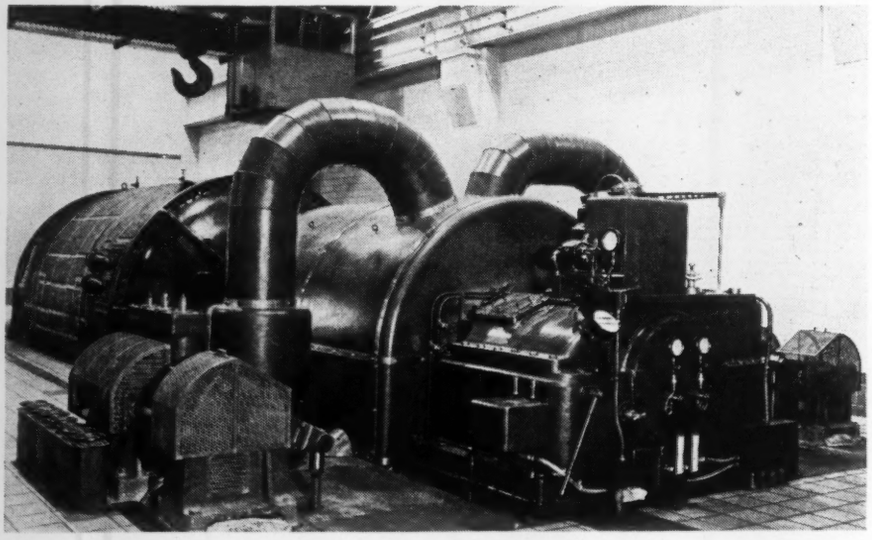
(An) Introduction to METALLÜRGY. By J. Newton. John Wiley & Sons, New York, 1938. Cloth, 6 × 9 in., 537 pp., illus., diagrams, charts, tables, $4. A presentation of fundamental metallurgical principles to serve as groundwork for advanced courses. Discusses structure, shaping and heat-treatment of metals and alloys, ores and ore dressing, hydrometallurgy and electrometallurgy, sampling, and the production of industrial metals.

INTRODUCTORY QUANTUM MECHANICS. By V. Rojansky. Prentice-Hall, Inc., New York, 1938. Cloth, 6 × 9 in., 544 pp., diagrams, charts, tables, $5.50. The book is intended for those who wish to become familiar with some of the simpler physical ideas and mathematical methods of quantum mechanics, either because of their intrinsic interest or as preparation for further study of the theory or its applications. The text is designed for graduate and advanced undergraduate study.

LUMBER, Its Manufacture and Distribution. By R. C. Bryant. Second edition. John Wiley & Sons, New York, 1938. Cloth, 6 × 9 in., 535 pp., illus., diagrams, charts, tables, $5. This book is intended as a text and reference book for instructors and students in forest schools. The text discusses equipment for manufacturing lumber, methods of manufacture, and markets and marketing. There is a bibliography and a glossary. The new edition has been revised and brought up to date.

MECHANICS OF MATERIALS. By P. G. Laurson and W. J. Cox. John Wiley & Sons, New York, 1938. Cloth, 6 × 9 in., 408 pp., illus., diagrams, charts, tables, $3.75. The fundamental treatment of general stresses, joints, torsion members, beams, columns, and combined stresses is covered in the first fifteen chapters. The next eight chapters discuss more specialized material, elastic energy, webs, eccentric loading, etc. A large number of problems are included, and various derivations and tables are appended.

MEHRSPINDELAUTOMATEN. By H. H. Finkelnburg. Julius Springer, Berlin, 1938. Cloth, 6 × 9 in., 203 pp., illus., diagrams, charts, tables, 19.80 rm. The development, types, range of operation, selection, and regulation of multispindle automatic machines are discussed. The machinery itself is fully described, the calculation and method of production of the necessary motions are considered, and the final section deals with auxiliary tools and special equipment.



TURBINE ROOM—ESSEX GENERATING STATION

(An inspection trip is planned to this Station during the Annual Meeting. See pages 985–986.)

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Streamlined Social Activities and Inspection Trips Supplement Technical Features of A.S.M.E. Annual Meeting, Dec. 5–9

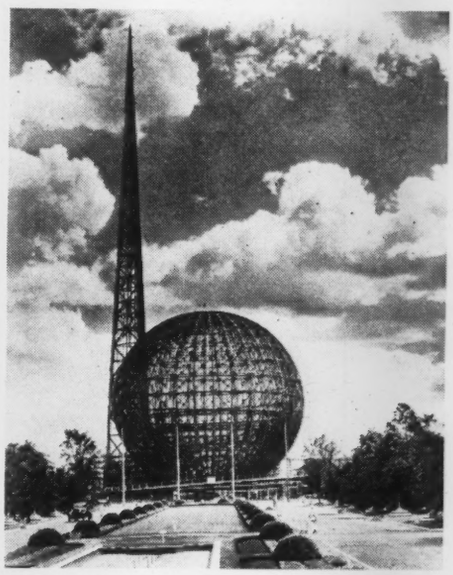
High Spots of Nontechnical Events

STREAMLINED in all its phases is the social program arranged for the 59th Annual Meeting of The American Society of Mechanical Engineers in New York, Dec. 5–9. It is a worthy supplement to the many interesting technical sessions which were outlined in the November issue of MECHANICAL ENGINEERING. Luncheons and dinners, trips by bus to near-by points and trips by motion picture to New Orleans and San Francisco, Honors Night with its traditional symbolism, and the Annual Dinner and Dance at the modernized Hotel Astor are just a few of the pacemakers of the 1938 Meeting.

Luncheons and Dinners

As usual, the first get-together luncheon of the Meeting will take place on Monday, Dec. 5, when Council members and the delegates of the Local Sections sit down to lunch after a morning spent in discussing Society business. Monday evening, the informal All-Members Dinner sponsored by the Junior members begins at 6 p.m. at the Roger Smith restaurant. Everything, including tips, will cost only $1.50 per person. Howard Lee Davis, guest speaker, will discuss in his humorous way the good points of junior engineers, basing his talk on his long years of experience as director of technical employment and training at the N. Y. Telephone Company. Another dinner that same evening, called the Time and Motion Study Dinner, has been arranged by the Management Division, which is also sponsoring a luncheon on Tuesday, Dec. 6, for plant-maintenance engineers. Wednesday noon will be the occasion of a flock of luncheons, chief ones being the textile, safety, and student affairs. Thursday evening will be the time and Midston House the place for the annual Railroad Division meeting and dinner.

But the big event of them all will be the Annual Dinner on Wednesday evening, Dec. 7, at the Astor Hotel at Times Square. This affair, with William L. Batt, past-president of the Society and modern industrialist, as toastmaster, will feature two well-known speakers: Dr. Harvey N. Davis, retiring president of the A.S.M.E., who has selected "An Engineer's Philosophy" as the topic for his presidential address; and Dr. Howard W. Haggard, director of the Laboratory of Applied Physiology of Yale University, who will give the tenth Thurston Lecture under the title of "Physiology for the Engineer." It was Dr. Haggard who reported recently in the New England *Journal of Medicine* on just how many whiskey highballs, gin cocktails, and beers can be imbibed before a man can be said to be "under the influence." If you want to know the results of his experiments on engineers, be sure to send in your reservation early in order to get choice locations. The presidents' reception and dancing will follow the after-dinner speaking.



COMMUNICATION PLAZA AT NEW YORK'S WORLD FAIR, 1939, AND INTRICATE STEELWORK OF 200 FT GLOBE AND 700 FT NEEDLE

(Excursion to World's Fair Grounds is planned during the Annual Meeting, December 5–9, 1938.)

Professional Divisions

For the purpose of discussing the professional divisions and interests of the members, a conference of representatives will be held the opening morning of the Meeting. Like the annual forums of the delegates of the Local Sections Groups, this conference is expected to give further coordination to the work of the Society and heighten the quality of its service.

Annual Business Meeting

On Monday afternoon at 4 o'clock, President Davis will call to order the 1938 Annual Business Meeting of the Society and introduce C. E. Davies, secretary, who will present in abstract form the annual report of the Council. Then the chairman of the Committee on Local Sections will read the names of the Nominating Committee for 1939, members for which were chosen at the seven Local Sections Group Conferences. It is sincerely hoped that every member in New York at the time will make every effort to attend this important meeting.

Honors Night

On Tuesday evening, the occasion for the presentation of honors and awards, the Towne Lecture will be delivered by Gerard Swope, president of the General Electric Company. His address will be on "Mechanical Engineering—Men, Materials, and Methods." The awards to be presented are listed in last month's issue of MECHANICAL ENGINEERING. It is also hoped that Major-General William H. Tschappat, recently elected to honorary membership in the Society, will be able to be present for the formal conferring of the honor.

Inspection Trips

This year, besides plant visits, there will be tours to many of the spots of general interest in New York City, including the World's Fair, Chinatown, Empire State Building, and Harlem.

Three generating stations, the Williams-

burgh plant in Brooklyn with new up-to-date additions, the Waterside station of the Consolidated Edison Company with its two 53,000-kw superimposed turbines, one by General Electric and the other by Westinghouse, and the Essex Station of the Public Service Electric and Gas Company in New Jersey with its new 50,000-kw turbine which went into operation in August, 1938, will give many visitors an opportunity to inspect the latest in power-plant equipment. Then, of course, there are the trips to the World's Fair and to Radio City with its Music Hall and television studios.

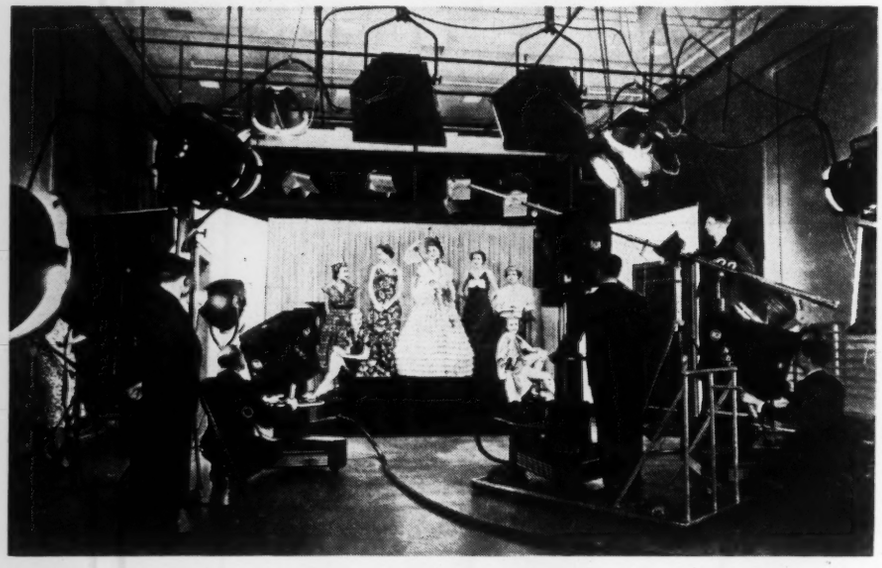
The Machine Shop Practice Division is arranging a visit to the plant of the American Machine Foundry Company.

Harry A. Cox, chairman of the Plant Visits Committee, has also arranged for a Grand Tour of New York City by bus, either in the day or evening, starting downtown with Chinatown and ending up in the night clubs of Harlem. Though not in the nature of a plant visit, a gala supper party will be held on Tuesday evening, following the Honors Night affair, at the International Casino with its unexcelled cuisine. On Thursday night, there will be a dinner party at Casa Manana.

Good Times for the Women

The women coming to New York are assured a good time by the New York members of the Woman's Auxiliary to the A.S.M.E. Plans now are as follows: *Monday:* Dinner, Engineering Woman's Club, visit to broadcasting studio, social evening with dancing and buffet supper at the Club . . . . *Tuesday:* Business Meeting of the Woman's Auxiliary to the A.S.M.E. at Society Headquarters; Fifteenth Annual Luncheon at the Cafe Francaise in Radio City followed by visits to a television studio and backstage of the Music Hall; Honors Night in the evening followed by the gala supper at the International Casino . . . . *Wednesday:* Bache Museum in the morning, World's Fair in the afternoon, and the Annual Dinner and Dance of the Society in the evening . . . *Thursday:* morning visits to the Cloisters or the Whitney Museum in Greenwich Village; the Annual Tea in the afternoon.

TURBINE GENERATORS AT WATERSIDE NO. 2
(An excursion to Waterside is scheduled for the Annual Meeting.)



A TRIP TO TELEVISION STUDIO IS SCHEDULED DURING THE ANNUAL MEETING

13th Annual Power Show

An added incentive for coming to New York for the Annual Meeting of the A.S.M.E. will be the 13th Annual National Exposition of Power and Mechanical Engineering to be held at the time of the Meeting at Grand Central Palace. The products to be shown there include stokers, boilers, heaters, refractories and insulation, power-plant equipment, instruments, piping, valves, air-conditioning and refrigerating apparatus, electrical apparatus, transmission equipment, materials-handling equipment, metals, machines and engines, and books on engineering.

College Reunions

A number of college alumni associations are holding luncheon or dinner meetings during the Annual Meeting of the Society. The names of the colleges and the day of their affairs are as follows: Brooklyn Poly, Thursday, dinner at 7 p.m.; Brown, Thursday, luncheon at 12:30 p.m.; Bucknell, Tuesday, luncheon at 12:30 p.m.; University of California, Thursday, luncheon; Case, Thursday, dinner meeting; Clarkson College, dinner at 7 p.m.; Cornell, Thursday, dinner at 6:30 p.m.; University of Michigan, Tuesday, luncheon, and Friday, dinner meeting; Michigan State College, luncheon at noon; New York University, Thursday, luncheon; Northeastern University, Thursday, luncheon; Pennsylvania, Thursday, dinner at 6 p.m.; Pratt, Thursday, dinner at 6:30 p.m.; Purdue, Thursday, dinner at 6 p.m.; Rutgers, Thursday, luncheon at noon; Stevens, Thursday, dinner-smoker at 6:30 p.m.; Yale University, Friday, smoker; Tufts, Thursday, luncheon at noon; and Worcester Poly, Thursday, dinner at 6 p.m.; Lehigh-Lafayette, Thursday, joint dinner.

Third Photographic Exhibit

During the week of the Annual Meeting there will be on exhibit technical and nontechnical photographs by members of the Society. In conjunction with this not-to-be-missed exhibit will be two motion pictures showing interesting scenes and sights to be seen during the all-expense A.S.M.E. trips to New Orleans in February at Mardi gras time and to San Francisco in July followed by a visit to Alaska.

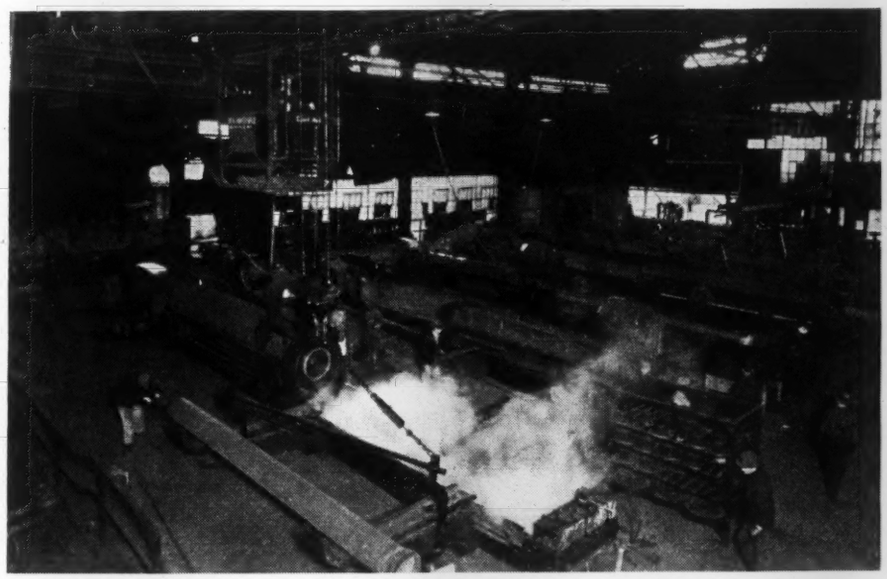
Library Exhibit

Members will be given an opportunity to visit the interesting and educational exhibit of books and drawings in the Engineering Societies Library, one of the largest engineering libraries in the world.

Registration Fee for Nonmembers at the 1938 Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1938 A.S.M.E. Annual Meeting. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before December 1 asking for a guest-attendance card for the Annual Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.



OPERATING FLOOR WHERE SUPER-DE LAVAUD CENTRIFUGALLY CAST IRON PIPE IS MANUFACTURED AT PLANT OF UNITED STATES PIPE AND FOUNDRY COMPANY IN BIRMINGHAM. A TRIP IS PLANNED TO THIS PLANT DURING THE A.S.M.E. TOUR TO NEW ORLEANS

(Plant equipped for production of pipe by this process in 3 to 24-in. size; also includes special foundry for manufacture of small and large-diameter fittings, sugar evaporators, etc.)

A.S.M.E. Spring Meeting at Mardi Gras Time, New Orleans, Feb. 23–25, 1939

Unusual Chance to Combine Festival, Meeting, and Southern Trip

WITH THE A.S.M.E. Spring Meeting scheduled for New Orleans, La., February 23 to 25, 1939, during the annual Mardi gras festival, an opportunity will be afforded to the members of the Society to enjoy this gala occasion and at the same time attend a national meeting of the Society with all of its many technical advantages.

Because of the great crowds usually in New Orleans at Mardi gras time, taxing the hotel facilities to the utmost, there has been planned an all-expense tour to bring the cost to a reasonable minimum and at the same time to assure sleeping accommodations for all members of the A.S.M.E. Tour.

Special Train Being Arranged

A special train is being arranged to travel via the Pennsylvania Railroad from New York on Saturday evening, February 18. It will stop in Cincinnati on Sunday where there will be sufficient time allowed for those wishing to attend church services and then start on again to Mammoth Cave, Ky., where time will be allowed for an extended sight-seeing trip through one of the natural wonders of the world. Dinner will be served at the Mammoth Cave Hotel and the group will leave late in the evening and arrive in Birmingham, Ala., at 8:00 a.m. on Monday morning.

A full day of visits to the iron-pipe factories of Birmingham will give the men an excellent chance to see the various steps in the manufacture of cast iron and other types of pipes. Plants of the National Cast Iron Pipe Company, the McWane Cast Iron Pipe Company, the United States Cast Iron Pipe Company, and the American Cast Iron Pipe Company are scheduled to be visited and the accompanying illustrations give an idea of what is in store for those members of the Society on the official tour.

Nor have the women been forgotten for this day—sight-seeing trips through the lovely residential areas of the city with luncheon at the country club and golf or bridge in the afternoon will make a busy day. In the evening both men and women will be guests at a banquet after which the Birmingham Section of the A.S.M.E. is to hold a get-together meeting. Late in the evening the train will leave for New Orleans, arriving Tuesday, February 21, the major day of the Mardi gras fun.

The City in Carnival Spirit

The whole city will be in carnival spirit, with business at a standstill, flags and buntings everywhere. Through the day and evening a series of costume parades with multitudes of floats will sweep down the main thoroughfare, while in the evening the whole city will be ablaze with colored lights. There is nothing like it to be seen elsewhere in this country—hosts of people travel thousands of miles to take part in the festivities. The day and night are crowded with thrilling contests as parade after parade sweeps down Canal Street, the widest thoroughfare in the United States.

The special A.S.M.E. train will be parked for occupancy on Tuesday evening and as it will be made up of cars containing bedrooms, compartments, and drawing rooms as well as sections, all classes of accommodations will be available. On Wednesday noon the entire party will be transferred with baggage to the Hotel St. Charles, headquarters for the Spring Meeting. This meeting will begin on Thursday morning, February 23, and will be held in part as a joint meeting with the Louisiana Engineering Society. It will continue through Thursday, Friday, and Saturday, terminating with a joint banquet on Saturday evening, followed by a reception and dancing.

Approximate Cost

The approximate cost (until final details are arranged) including rail and Pullman transportation for the round trip, the entire expense of visit to Mammoth Cave and Birmingham, Ala., and hotel accommodations during the

A.S.M.E. Spring Meeting Tour

Ernest Hartford, Assistant Secretary,
The American Society of Mechanical Engineers,
29 West 39th St.,
New York, N. Y.

Please send further details and literature regarding the Tour which will be conducted to the Spring Meeting of the Society at New Orleans during Mardi gras Week in February, 1939. There will probably be .....persons in my party, and we wish the following accommodations:

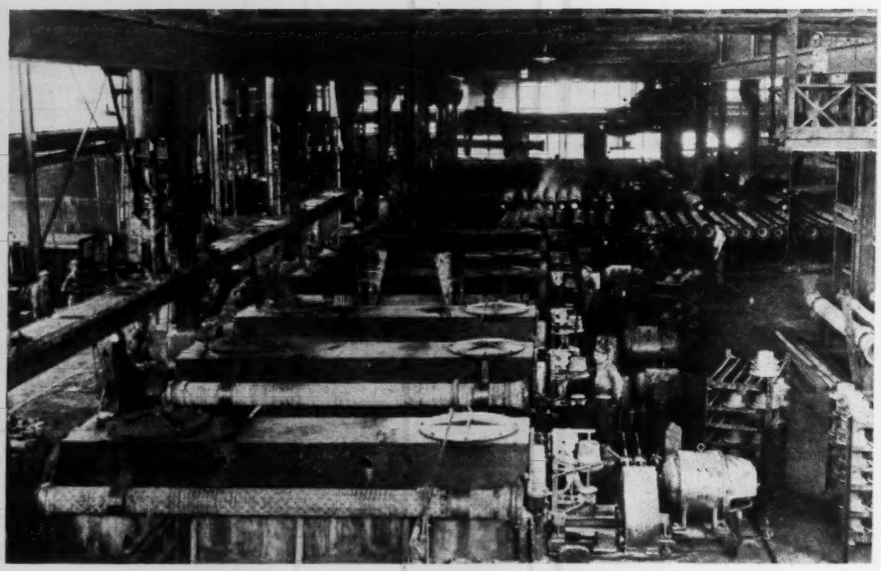
Upper berth..... Lower berth..... Compartment (two persons).....

Bedroom (two persons)..... Drawing room (two persons).....

Drawing room (three persons).....

(Signed).....

Address.....



BATTERY OF 12 CASTING MACHINES AT PLANT OF AMERICAN CAST IRON PIPE COMPANY IN BIRMINGHAM TO WHICH TRIP IS PLANNED ON A.S.M.E. TOUR TO NEW ORLEANS

(Cast-iron pipe is monocast centrifugally in sand-lined molds.)

meeting, Pullman and meals on the going and return trips—can be had for as low as $125. This will include a complete ten-day trip with all expenses, except meals in New Orleans.

For those who wish to spend a longer period in the South, side trips will be possible such as a sixteen-day cruise to the Gulf of Mexico and Caribbean Sea with stops at Havana, Canal Zone, and Costa Rica, at a minimum of $175.

Others may be interested in returning via Florida or Gulf Coast points and this can be arranged according to the individual's preference. However, those desiring to return to the North at the conclusion of the meeting will leave New Orleans Sunday evening, February 26, and be in New York and other northern points by Tuesday morning in time for business.

A.S.M.E. Cavitation Committee of Hydraulic Division Meets at Safe Harbor

A MEETING of the Cavitation Committee of the Hydraulic Division of The American Society of Mechanical Engineers was held in Lancaster and Safe Harbor, Pa., Sept. 30 and Oct. 1, 1938. The meeting was arranged in honor of Professor Wilhelm Spannhake of Karlsruhe, Baden, Germany, who is visiting in this country and was made possible by the hospitality of the Pennsylvania Water & Power Company.

Fifty in Attendance

The first session was called to order on Friday afternoon at the Safe Harbor water power plant by L. F. Moody, chairman of the Cavitation Committee. The attendance was fifty. The Safe Harbor plant, where Professor Spannhake's influence in hydraulic design was felt so strongly, was a particularly appropriate setting for the gathering. The session was conducted in an informal manner, in which discussions were opened by gentlemen who had been asked to prepare a few notes in advance, merely for the purpose of covering certain topics. R. E. B. Sharp, of the I. P. Morris division of the Baldwin Southwark Corporation, presented a discussion of the new cavitation laboratory recently built by that company. The test equipment of this laboratory consists of a closed system in which the water is circulated by pumping, and flow measurement is made by a venturi meter. Heads up to 28 ft can be used with a maximum draft head of 25 ft at the runner. This permits a minimum value of sigma of about 0.3. A very interesting comparison was presented which showed the results obtained at this laboratory with an 11-in. model runner exactly analogous to a 16-in runner which had already been tested at the Holtwood laboratory. It was shown that the results agreed remarkably well. G. F. Wislicenus, of the Worthington Pump & Machinery Company, next discussed his efforts in attempting to provide some measure of the cavitation limits of centrifugal pumps. He outlined the ideas he had presented in a paper at the Los Angeles meeting of the Society and added thereto some newly developed charts which would serve to determine limiting conditions under which centrifugal pumps would be safe from cavitation troubles. H. S. Van Patter, of the Dominion Engineering Works, then described some work which had been done by his company on cavitation testing of both hydraulic turbines and centrifugal pumps. The opening remarks of these three gentlemen served to bring forth a considerable amount of discussion of an informal nature. Among those taking part was Prof. P. Danel, of Grenoble, France, who described work which had been done in France along these lines. Upon adjournment of this meeting, the group proceeded to the Stevens House, Lancaster, where they met informally for dinner.

The meeting on Saturday morning was held in the ballroom of the Stevens House with C. F. Merriam presiding. Professor Spannhake opened the morning discussion with the presentation of the recent results which he has obtained in his laboratory on the failure of metals under cavitation conditions. Some interesting photomicrographs were shown, which showed the damage resulting after a short time from cavitation. Some slides in natural color showed also the color conditions resulting from this same effect. Professor Spannhake stated that he was now building equipment of the vibratory type for further studies along these lines. Prof. H. A. Thomas, of the Carnegie Institute of Technology, showed a movie film illustrating cavitation conditions in the entrance to a discharge conduit under a dam. He described the tests which had been made on models for the purpose of changing the design of these intakes for the purpose of reducing the damage and erosion due to cavitation. J. M. Mousson, of the Pennsylvania Water & Power Company, presented an outline of the work which had been done in studies dealing with the operating conditions at the power plants of his company for the purpose of avoiding the troubles incident upon cavitation. Among other things he spoke of the results obtained by the admission of air for the purpose of reducing vibration, and also to permit a greater output from some of the machines. With the subjects having been opened up in an informal way, discussion followed at considerable length. Those who attended the meeting felt that the exchange of ideas was very valuable. The meeting adjourned at noon. The Society is indebted to the local committee for carrying out arrangements for this unusual international gathering which was participated in by engineers from France, Germany, Canada, Czechoslovakia and Sweden.—F. W. SWITZER.[1]

Cavitation Experiments at Toronto

Cavitation experiments which have been in progress in the hydraulic laboratory of the University of Toronto since 1934, were reported at the Safe Harbor meeting. The experimental work has been carried out by G. Ross Lord, with the active cooperation of R. W. Angus, fellow A.S.M.E., head of the department of mechanical engineering.

A cavitation test stand of the usual venturi type is set up in the laboratory. The water is drawn from a constant-head tank and, after passing through the unit, flows into a weir tank and over a suppressed sharp-crested weir. Pressure measurements on the venturi walls were made, using a mercury manometer connected to carefully made piezometer openings.

The tests so far completed fall under two general headings: Pressure measurements on the walls of the unit and pressure measurements on objects placed at the throat section with and without cavitation.

[1] Secretary A.S.M.E. Hydraulic Division.

The curves of pressure measurements on the channel walls are similar to the results obtained in like units elsewhere.

Pressure measurements have also been made on one-quarter and one-half inch cylinders located at the throat section of the canal, with their axes at right angles to the axis of flow.

Another series of tests was carried out to investigate the best shape for the leading edge of turbine blades. These tests were suggested by work done in the Karlsruhe laboratory of Professor Spannhake. An assumption was made that the leading edge of the blades would conform to a semiellipse in shape. A theoretical consideration, based upon this assumption, indicates that such an elliptically shaped nose should have a ratio of axis of 5 to 1. Briefly, the theoretical basis for this result is arrived at by considering the flow about a cylinder. This flow may be expressed mathematically and by conformal transformation, the flow about an ellipse deduced. Four blades of brass were made, having different-shaped leading edges, and pressures were measured beginning at the blade tip and extending back past the middle of the elliptical nose.

A decision has not yet been made concerning further cavitation research at this laboratory.

More Than 350 Attend Second Joint Coal Meeting of A.S.M.E. and A.I.M.E. at Chicago

Excellent Technical Program Dealing With Problems of Producer and Consumer, Purchasing, Underfeed Stokers, Mine Practice, and Safety

MORE THAN 350 engineers attended the second joint meeting of the Fuels Division, A.S.M.E., and the Coal Division, A.I.M.E., held October 13 to 15 at the Palmer House, Chicago. The Western Society of Engineers, the Illinois Mining Institute, the Indiana Mining Institute, and the Chicago Sections of the A.S.M.E. and A.I.M.E. cooperated in sponsoring the meeting.

Coal Problems of Producer and Consumer

Following the lead of last year's highly successful meeting at Pittsburgh, technical sessions were devoted to study of problems of coal producer and coal consumer. Of real interest to both were papers on "The Bureau of Mines Experimental Coal Hydrogenation Plant," by A. C. Fieldner and H. H. Storch, Bureau of Mines, and on "Effect of Preparation on Ash Fusibility, as Revealed by a Study of Selected Illinois Mines," by L. C. McCabe and O. W. Rees, of the Illinois State Geological Survey.

Pointing out that the essential chemical difference between bituminous coal and petroleum lies in the carbon-hydrogen atomic ratio, Dr. Storch outlined the development of coal hydrogenation processes and gave a detailed description of the Bureau of Mines experimental plant. Built to study adaptability of American coals to hydrogenation, it consists essentially of a hydrogen-production plant and a coal-liquefaction plant. The paper concluded with data on hydrogenation of Bruceton coal from the Pittsburgh seam.

Samples from ten mines, representing all important beds and producing districts of Illinois, were float-and-sink tested. From the float-and-sink fractions, samples were studied for ash-fusion properties. According to Mr. McCabe, greatest difference in ash-fusion temperature was obtained in sized coals of narrow specific-gravity range.

Of major interest to engineers responsible for buying and burning coal was a session devoted to low-grade coals, and to a panel discussion on coal purchasing. After defining low-grade coal, Ollison Craig, Riley Stoker Corporation, devoted the bulk of his paper "Use of Low-Grade Coals in Modern Steam-Generating Equipment" to a discussion of firing in powdered form. Major points of burner and furnace design were illustrated with cross sections of boiler furnaces.

Panel Discussion on Coal Purchasing

Five points of view were represented in the panel discussion on coal purchasing: T. W. Harris, Jr., E. I. du Pont de Nemours & Co., spoke for the purchasing agent; B. Gebhardt, Chicago Wilmington and Franklin Coal Co., represented the viewpoint of coal sales; T. Jeffords, city of Detroit, told of purchasing for a municipality; A. W. Thorson, The Detroit Edison Co., presented the consumer's side; and J. B. Morrow, Pittsburgh Coal Co., spoke from the standpoint of coal preparation. All agreed on the difficulty of the problem, and the need for standard indexes of coal qualities was emphasized.

Of interest to consumers of coal were two papers on domestic underfeed stokers, "Some Aspects of Combustion in Small Underfeed Stokers," by C. A. Barnes, Battelle Memorial Institute, and "Iowa Coal as a Domestic Stoker Fuel," by M. P. Cleghorn, Iowa State College.

In concurrent technical sessions, numerous papers on mine practice and safety were presented to two mining-engineering groups, and a diversified set of papers was given before the A.S.M.E. and W.S.E. groups. Illustrating with case studies, R. F. Hall and E. P. Partridge of Hall Laboratories, Inc., described "Conquering Nightmares of Water Conditioning." W. R. Bean, Whiting Corp., discussed "Coal for Metallurgical Furnaces" and J. F. Peterson, Chicago Tunnel System, told of "Chicago Tunnel Facilities for Transporting Coal and Ashes." Immediately after the session, an informal inspection of the tunnel system was made.

Social activities of the meeting included get-together luncheons, a buffet dinner followed by a showing of the technicolor sound film "Steel—Man's Servant," and a banquet. Dr. W. L. Abbott, past-president of both the A.S.M.E. and the W.S.E., acted as toastmaster, introducing Howard N. Eavenson, past-president, A.I.M.E., who spoke on "An Ancient Law and Coal."

The last day of the meeting was given over to inspection trips to a strip coal mine of the Northern Illinois Coal Co. at Wilmington, Ill., to the plant of the Inland Steel Co., at Indiana Harbor, Ind., to the Goodman Manufacturing Co., and to Fisk Station, Chicago.

LOUIS N. ROWLEY, JR.[1]

[1] McGraw-Hill Publishing Co., New York, N. Y. Jun. A.S.M.E.

AT THE COAL MEETING

(R. A. Sherman, Battelle Memorial Institute; Joseph Harrington, Northern Illinois Coal Co., E. R. Kaiser, and C. A. Barner, Battelle Memorial Institute.)

1937 Report on Oil-Engine Power Cost Now Available

Tenth Year of Publication by A.S.M.E. Oil and Gas Power Division

DIESEL operators, Diesel manufacturers, consulting engineers, oil companies, and others concerned with the operating costs of Diesel plants will find the recently published report on Oil-Engine Power Cost for 1937 a source of valuable information. This report has been prepared each year under the sponsorship of the A.S.M.E. Oil and Gas Power Division by a subcommittee of which H. C. Major has served as chairman for the last six years.

Purpose of Report

The purpose of the report is to record and present actual operating results of Diesel-engine generating plants in the United States. Plants are classified as building power plants, industrial power plants, municipal power plants, private power-company plants, and municipal pumping plants. In addition to this classification, the plants are keyed so as to indicate whether they are base-load, complete power, peak-load, or stand-by plants. Thus a reader of the report is able to identify and study the type of plant in which he is particularly interested.

The report presents information on production costs, but includes no data on investment costs or fixed charges. Production cost in the report is defined as the sum of the following costs: Fuel, lubrication, attendance and superintendence, supplies and miscellaneous, and engine and plant repair. It presents data from 156 oil-engine generating plants containing 441 engines totaling 246,725 rated horsepower. The total net output for the 156 plants tabulated in the 1937 report amounted to 329,101,233 kwhr. Each of the plants submitted data for a period of exactly twelve months, with only three exceptions. The initial report in 1929 contained data on only 27 plants containing a total of 68 engines and generating a total of approximately 75,000,000 kwhr.

Data in Tabular Form

The information is presented in the form of three tables. Table 1 presents information on production cost for each of the 156 plants covered by the report, including capacity, load, and net-output data together with various unit costs per kilowatthour for each of the items making up total production cost. The last column of the table gives the total production cost of each plant.

Table 2 gives the individual and total production costs for each of two or more years for 136 plants. Hence this table shows the comparative production costs of each plant for each year for which data are available. Each succeeding year adds to the value of this table and already the number of plants reported for five successive years or over has reached 86.

Data on engine details and operating information are given in Table 3, which includes, in addition to engine data, information on lubrication, fuel, engine loading, cooling systems, waste-heat utilization, maintenance and repairs, enforced shutdowns, and attendance labor.

In order that the data on fuel and lubricating-oil economies may be easily assimilated these data have been plotted in chart form with median and boundary lines included to assist the eye in subdividing the plotted data.

Fig. 1 presents the lubricating-oil economies of 111 plants generating 95 per cent or more of their outputs by full-Diesel units. Fig. 2 gives fuel economies of 117 full-Diesel plants. The lubricating oil and fuel economies are given in gross kilowatthours per gallon and are plotted against plant running capacity factor in per cent. Fuel economies of 217 full-Diesel engines are shown plotted against engine running capacity factors in Fig. 3.

Copies of the report can be obtained from the Publication-Sales Department of the A.S.M.E. at a cost of one dollar per copy. Lower prices are available for quantity lots.

Applied Mechanics Division to Hold Dinner

THE Applied Mechanics Division of the A.S.M.E. will, as usual, hold its Division Dinner during the Annual Meeting of the Society. This year it will be held at the Midston House, 22 East 38th Street, New York, N. Y., on Tuesday evening, December 6, 1938, at 6:30 p.m. Ladies will be invited and dress will be formal.

A.S.M.E. Calendar

of Coming Meetings

December 5–9, 1938
Annual Meeting
New York, N. Y.

February 23–25, 1939
Spring Meeting
New Orleans, La.

July 10–14, 1939
Semi-Annual Meeting
San Francisco, Calif.

A.S.M.E. Woman's Auxiliary Holds Bridge Benefit

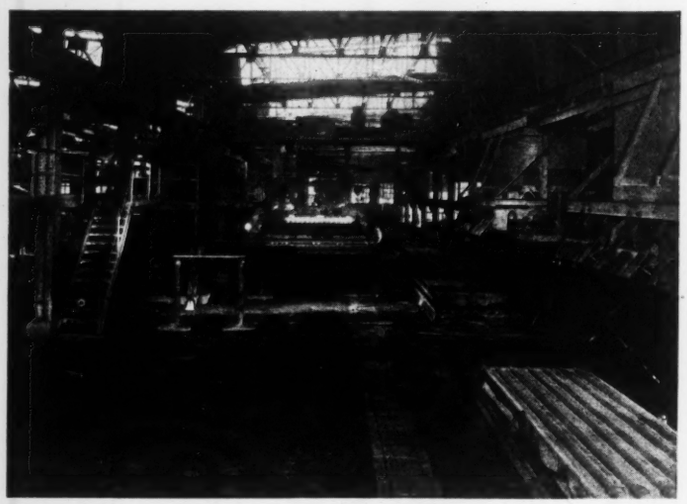
THE WOMAN'S Auxiliary to The American Society of Mechanical Engineers held its November meeting at the Engineering Woman's Club with a dessert bridge for the benefit of the Educational Fund. Mrs. F. M. Gibson and her committee acted as hostesses.

At this meeting also the program for the Annual Meeting of 1938 was discussed as it is the fifteenth anniversary of the organization.

BURTIE HAAR.
Chairman, Publicity Committee

Mumford Elected Chairman of Library Board

THE LIBRARY BOARD at its meeting of Oct. 14, 1938, elected as its chairman for 1939, A. R. Mumford, member A.S.M.E., and as its vice-chairman, J. W. Laist. W. S. Barstow, J. K. Finch, W. D. B. Motter, Jr., and W. I. Slichter were chosen members of the Executive Committee.



PIPE FOUNDRY OF THE MCWANE CAST IRON PIPE COMPANY IN BIRMINGHAM WHERE INSPECTION TRIP IS SCHEDULED ON SPRING MEETING TRIP

(Pipes are cast horizontally in sand molds, with sand cores, and poured with multiple-lipped ladles.)

Local Sections Delegates for 1938–1939 Elected at Seven Group Conferences

Fourteen Representatives Will Meet in New York During Annual Meeting

TWO DELEGATES were elected at each of the seven Group Conferences of Local Sections held during October in New Britain, Conn., New York, N. Y., Philadelphia, Pa., Memphis, Tenn., Columbus, Ohio, Tulsa, Okla., and Los Angeles, Cal. These fourteen men will represent the 71 Local Sections at the Annual Meeting of The American Society of Mechanical Engineers in New York City, Dec. 5–9, where they will discuss together, and then jointly with the Council of the A.S.M.E., matters of Society policy.

Following is a list of the 1938 delegates and their affiliations: *Group I*, C. P. Howard, Worcester Section, and R. A. Spence, Boston Section; *Group II*, John M. Driscoll and Charles A. Hescheles, Metropolitan Section; *Group III*, Paul B. Eaton, Anthracite-Lehigh Valley Section, and Frederick C. Stewart, Central Pennsylvania Section; *Group IV*, W. E. McDowell, Charlotte Section, N. C. Ebaugh, Florida Section, and Harry R. Pearson, North Texas Section (alternate); *Group V*, E. R. McCarthy, Cleveland Section, and C. J. Freund, Detroit Section; *Group VI*, D. K. Hutchcraft, Mid-Continent Section, and R. E. Turner, Chicago Section; *Group VII*, A. L. Hill, Colorado Section, S. F. Duncan, Los Angeles Section, and W. D. Turpin, Utah Section (alternate).

Other Local Sections News

Connecticut Local Sections Joint Meeting in Meriden

200-Inch Telescope Described by Whipple and Karelitz

A JOINT MEETING was held on Nov. 1 in the State Trade School auditorium, Meriden, Conn., by the Bridgeport, Hartford, New Britain, New Haven, Norwich, and Waterbury Sections of The American Society of Mechanical Engineers. The first speaker, Dr. F. L. Whipple, in charge of telescopes at Harvard Observatory, answered the question, "Why a 200-Inch Telescope?" The second speaker, M. B. Karelitz, mechanical engineer on the 200-inch telescope of the astrophysical observatory, California Institute of Technology, discussed "The Mechanical-Engineering Problems Involved in the Building and Erection of the 200-Inch Telescope."

Anthracite-Lehigh Section Meets in Bethlehem, Pa.

Assembled in the Packard Laboratory of Lehigh University, Bethlehem, Pa., on Oct. 28, 40 members and guests of the Anthracite-Lehigh Section heard a paper on "Steel Forgings" by Paul E. McKinney, metallurgical engineer, Bethlehem Steel Co. After reviewing the history of his subject, Mr. McKinney discussed the latest developments and practices in forging, illustrating his paper with slides. Especially interesting was his explanation of the importance of plastic flow.

Atlanta Section Holds Three Meetings in October

Meeting at the Atlanta Athletic Club on all occasions, members of the Atlanta Section on Oct. 10 heard a paper on the "Cottrell Precipitators at the Atkinson Plant," presented by R. N. Benjamin, member A.S.M.E., and engineer with the Georgia Power Co. "Flax in the Textile Industry" was the topic of the talk given on Oct. 24 by C. G. Worthington, member A.S.M.E., of the Georgia State Engineering Experimental Station. Through the kindness of the R. J. Reynolds Tobacco Co., a film, showing the manufacture of cigarettes from the raw tobacco to the finished product, was the feature of the Oct. 31 meeting.

Industrial Preparedness Discussed at Baltimore

Speaking before a group of 55 members of the Baltimore Section and 10 guests, Major S. B. Ritchie, Ordnance Department, U. S. Army, discussed the subject of "Industrial Preparedness." The talk dealt with the activities of the War Department in planning for the procurement of munitions and for the mobilization of industry to support the military effort in case of an emergency. According to Major Ritchie, plans are being revised continually to meet changing conditions in industry.

Birmingham Business Meeting

The Oct. 28 meeting of the Birmingham Section was devoted to a discussion of business, committee reports, and plans for attending the Annual Meeting of the Society in New York in December.

Central Illinois Meets at University of Illinois

The first meeting to be held at the University of Illinois under the sponsorship of the Central Illinois Section took place on Oct. 13. Before 30 members and 70 student members, C. G. A. Rosen, member A.S.M.E., and engineer with the Caterpillar Tractor Company, talked on "The Life History of the Diesel Engine." Many projects under way in the research laboratories of his company were explained and illustrated by Mr. Rosen.

Economics at Central Indiana Attracts 165 Members and Guests

At a meeting in Kokomo, Ind., on Oct. 12, attended by 96 members and 69 guests, the Central Indiana Section had as guest speaker, G. W. Starr, director of the school of business at the University of Indiana. His paper, entitled "Popular Economic Beliefs," covered such topics as the gold standard, public-works administration, price fixing of industrial and farm products, and increasing labor's wages.

Chicago Section Plans Three Meetings in December

The Chicago Section is entering the third month of a year's program that includes thirty-

REPRESENTATIVES OF LOCAL SECTIONS AT GROUP IV CONFERENCE, MEMPHIS, TENN., OCT. 23–24, 1938

(Seated, left to right: A. P. Keisker *Savannah*, W. R. Woolrich *Local Sections Committee*, W. E. McDowell *Charlotte*, chairman of conference, N. C. Ebaugh *Florida*, secretary of conference, and J. M. Todd, Vice-President of the Society. Standing, left to right: D. D. Alton *South Texas*, Mack Rust *Memphis*, K. P. Kammer *New Orleans*, E. G. Hoefer *Raleigh*, H. R. Pearson *North Texas*, W. Joe Moore *Birmingham*, J. B. Jones *Virginia*, T. E. Bell *Atlanta*, E. A. Harper *Atlanta*, H. H. Iler *Greenville*, and W. R. Chambers *Knoxville*.)

five scheduled meetings. Because of the holiday season, only three meetings will be held in December. The first one, on December 6, is sponsored by the Manufacturing Division under the chairmanship of Robert Erickson. R. S. Perry, vice-president of the Ingersoll Milling Machine Co., will discuss "Machinery Purchasing."

The Power and Fuels Divisions with H. F. Hebley as chairman, will hear E. L. McDonald, a member of Power Test Code No. 4 Subcommittee, talk on the "Heat Balance Method of Boiler Testing." This talk, to be held during the second week of December, is very timely inasmuch as the Test Code Committee is at present working up a proposed standard heat-balance method for boiler testing.

On December 20, the Junior Group will be host to the Student Branches from Northwestern University, Armour Institute of Technology, and Lewis Institute. A symposium on "The Profession of Mechanical Engineering" is being planned, at which a number of prominent Chicago members of A.S.M.E. will present short discussions, following which the meeting will be given over to questions. Charles Gollin is chairman of the Junior Group.

Cleveland Section Draws Capacity Audience of 200

Modern Diesel locomotives was the subject of a talk by L. Caldwell, educational director, Electromotive Corporation, on Monday evening, Nov. 7, before 200 Cleveland Section members and guests. According to a report received the next day from E. R. McCarthy, secretary of the Section, Mr. Caldwell discussed locomotive designs and operating records in switching and trunk-line service.

Vice-President Pigott Speaks at Columbus

R. J. S. Pigott, vice-president of the Society, was the guest speaker at a meeting of the Columbus Section on Oct. 15. His paper was entitled "Petroleum Production."

Cincinnati and Dayton Hold Joint Meeting

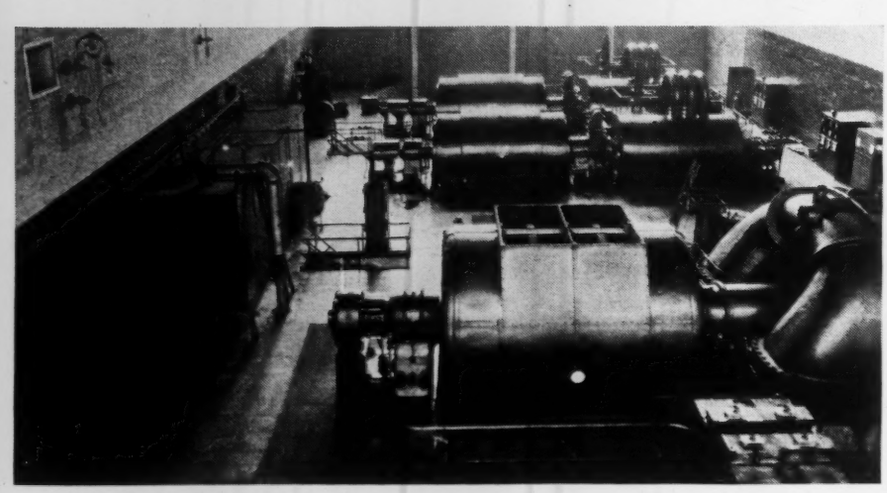
A joint meeting was held in Dayton on Oct. 27, by the Dayton Section and the Cincinnati Section of the A.S.M.E. In the afternoon, an inspection trip was made to the Millers Ford power plant. In the evening, following dinner at the Engineers Club, A. R. Smith, member A.S.M.E., and engineer, General Electric Co., described the boilers while H. J. Kerr, member A.S.M.E., engineer, Babcock & Wilcox Co., discussed the boiler.

Detroit Section Continues Successful Trip Meetings

Because of the success of the trip and meeting in October, Detroit Section had a similar affair in November. Following the inspection of the Mistersky power station of Detroit's Public Lighting Commission, the members enjoyed a technical paper on "Feedwater Treatment," presented by C. H. Fellows of The Detroit Edison Company at that concern's Delray plant auditorium on Nov. 15. Mr. Fellows discussed the general problem of feedwater and boiler-water treatment, pointing out the changes occurring as a result of operating experience and the use of higher steam pressures and temperatures.

Knoxville Section Conducts Elizabethton Meeting

On Oct. 14, following luncheon at the Franklin Club in Elizabethton, members of the Knoxville Section and their guests, after a few words of welcome from E. Torok, member A.S.M.E., listened to a short talk by D. R. Shearer, member A.S.M.E., on the "Obligations of the Engineer." Then the whole group embarked on a special train, furnished through the courtesy of the E.T. & W.N.C. Railway, for a trip to the Gorge—one of the most beautiful places of East Tennessee. In the evening, after dinner, James Ellis, chairman of the Section, introduced M. B. Conviser, engineer, Tennessee Eastman Corporation, who talked on "Economies of Heat Transfer," and H. B. Huddle, professor of chemistry at State Teachers College, who discussed "Matter."



ON THE EXCURSION PROGRAM FOR THE 1938 ANNUAL MEETING

(Main operating floor of boiler room, 1936 Extension of Williamsburg Power Station.)

Los Angeles Meets in Department Store

At a meeting of the Los Angeles Section on Oct. 21 in Barker Bros. store, Claude A. Buss discussed "Economic Aspects of World Affairs," and D. E. Delmar, junior member A.S.M.E., described the DC-4 airplane.

Louisville Section Has Joint Meeting With A.I.E.E.

Oct. 28 was the date of the joint meeting of the Louisville sections of the A.S.M.E. and A.I.E.E. at the University of Louisville. Dean F. L. Wilkinson, Jr., spoke on "Barriers to the Industrial Development of the South," in which he showed the growing lack of balance between outside and locally owned industries, a lack of research laboratories, and the great need for properly trained skilled workers.

Plans for New U. S. Ships Given at Metro Meeting

The complete program of the U. S. Maritime Commission to build a comprehensive merchant marine was outlined by J. E. Schmeltzer, member A.S.M.E., on Nov. 9 before 300 members of the Metropolitan Section, A.S.M.E. In a talk, which was technical in most aspects and which covered many of the mechanical details of ships in building stages, Mr. Schmeltzer described forty modern freight, passenger, and combination types of ships including one transoceanic passenger ship to be finished in 1940; twelve high-speed tankers, four fast-freight vessels, twenty cargo ships of special design, and three combination passenger and freight ships for use on the Mississippi.

Mid-Continent Committee Chairmen Appointed

The following were appointed by D. K. Hutchcraft, chairman of Mid-Continent Section, as chairmen of their respective committees with the privilege of selecting their own members to serve with them: Program, H. R. Auerswald; Entertainment, O. L. Olsen; Petroleum Division, Frank Stivers; Research, E. E. Ambrosius; and Membership, Fred Stewart.

Latest Welding Developments Discussed at Milwaukee

An illustrated lecture on the "Latest Developments in Welding" was presented on Oct. 27 by L. J. Larson, welding engineer, before the Milwaukee Section.

Uses of Neoprene Described at New Britain Meeting

H. L. Lawrence, E. I. du Pont de Nemours & Co., discussed "Neoprene, Its Manufacture, Properties, and Uses," at a meeting of the New Britain Section on Oct. 19.

Get-Acquainted Meeting of New Haven Section

Gathering in the Graduates Club in New Haven on Oct. 26, members of the New Haven Section spent a sociable evening getting acquainted with each other and viewing two sound motion pictures.

North Texas Hears About Engineering Leadership

Before a group of fifty members and guests of the North Texas Section on Oct. 17, Julian B. Thomas, member A.S.M.E., talked on "Training Engineers for Leadership." According to Mr. Thomas, the three essentials of engineering leadership are (1) understanding human nature, (2) ability to talk and think, and (3) rhythm and poise.

E. J. Abbott Talks Before 205 Oregon Engineers

"Sounds, Ears, Noises, and Relation to Machinery" was the title of the paper presented by Dr. Ernest J. Abbott, past-president of the Society, before 205 members and guests of the Oregon Section on Oct. 7, at Portland.

Philadelphia Conducts Ordnance Meeting

In an effort to bring before engineers and manufacturers of the Philadelphia area the need of cooperation between the Ordnance Department, U. S. Army, and local industry, the Philadelphia Section sponsored a program of two sessions on Nov. 9. Speakers and their topics at the afternoon session were Col. G. F. Jenks, talking on "Manufacturing of Welded Gun Carriages," and Lieut. Col. L. H. Campbell, Jr., speaking on "Manufacturing Problems of Artillery Ammunition." At the dinner meeting in the evening, Brigadier General C. T. Harris, Jr., explained "Plans for Industrial Mobilization." It is interesting to note that Colonel Jenks has been scheduled to give a paper at one of the technical sessions of the 1938 A.S.M.E. Annual Meeting in New York.

Von Gontard Night in St. Louis Attracts 180

R. W. Merkle, program chairman of the St. Louis Section, reports that 180 members were guests of Adalbert von Gontard, member A.S.M.E., and vice-president, Anheuser-Busch, Inc., at a smoker given on Oct. 14. After the introduction of the new officers, there followed a floor show, group singing, and refreshments. On Oct. 28, at a meeting in the Engineers Club, Don Allshouse reviewed the "Results of Research Into Steam Flow Type Regulators."

Rock River Valley Organizes Council

Walther C. von Fischer, secretary of the Rock River Valley Section, reports the organization of the Rock River Valley Engineering Council, composed of the local branches of the A.S.M.E., A.S.M., and Society of Production Engineers, and the Rockford Engineering Society. The new Council's first venture was a meeting of interest to engineers, executives, and foremen, held on Nov. 8 in the Hotel Nelson. Charles Andrews spoke on the "Need of an Engineering Council," and R. N. McMurray, executive secretary of the Psychological Corporation, talked on "Training of Foremen and Supervisors in Handling Employee-Relations Problems."

E. J. Abbott Speaks in San Francisco

"Elimination of Noise" was the subject of the talk presented before 200 members and guests of the San Francisco Section, Oct. 11, by Dr. Ernest J. Abbott, past-president of the Society. His paper covered the elimination of noises of all kinds, their meaning, measurements of quality, and intensity, all illustrated by various pieces of apparatus and slides. H. B. Langille, secretary of the Section, highly recommends Dr. Abbott to other Sections.

Fluorescence Subject of Schenectady Session

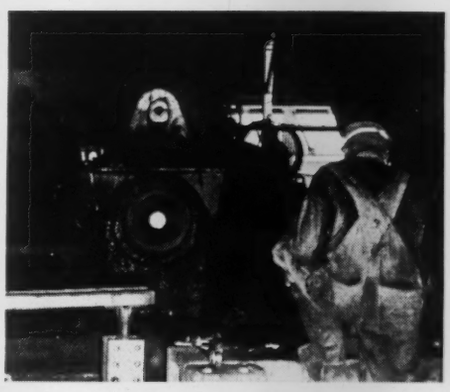
About 50 members turned out on Oct. 27 to hear a comprehensive discussion by Dr. Saul Dushman on fluorescence, including the properties of various materials, the mechanism of light production, characteristics of the light produced, and the field of application in its present state of development.

450 Present at South Texas Meeting

At its Oct. 31 meeting in Houston, Texas, the South Texas Section had present 40 members and 410 guests to listen to a paper on "Adventures in Electricity," given by Dr. Phillips Thomas. He described electric air cleaners, electric card sorters, and atom smashers.

Modern Ideas of Matter At Toledo by Osgood

Dr. Thomas H. Osgood, head of the physics department of the University of Toledo, and a recognized authority on nuclear physics, gave a lecture before the Toledo Section, Oct. 20, on "Modern Ideas of Matter." It was an interesting exposition of the structure and behavior of the atom. Special reference was made to energy levels and to the number of electrons associated with the nucleus of the atom. The material in this lecture was different in that the things discussed were submicroscopic rather than microscopic.



DELAVAUD CASTING MACHINE AT NATIONAL CAST IRON PIPE COMPANY IN BIRMINGHAM (To which a trip is planned on A.S.M.E. tour to New Orleans.)

Utah Section Members Also Hear Dr. Abbott

Dr. Ernest J. Abbott, on his tour of the West, spoke on Oct. 17 to the members of the Utah Section on his work in noise elimination.

Virginia Section Has Interesting Meetings

The Oct. 29 meeting held jointly with the V.P.I. Student Branch is described in the Student Branch News of this section. Then on Nov. 18, a joint meeting was held by the Virginia Section with the Central Virginia Engineers Club in Richmond, Va. The principal speaker was Thomas B. Morton, commissioner, department of labor and industry, Commonwealth of Virginia. His talk dealt with needed legislation pertaining to boilers, elevators, fire escapes, and mines.

Washington, D. C. Section Hears Colonel Weeks

Talking on "Track-Type Tractors for Industrial and Military Use," Col. Paul Weeks used sound movies and slides to illustrate his paper which was presented before the Washington, D. C., Section on Oct. 13.

150 Welcome Dr. Abbott to Seattle, Washington

More than 150 members and guests of the Western Washington Section turned out on Oct. 6 to meet and hear Dr. Ernest J. Abbott, past-president of the Society, talk on "Elimination of Noise."

Modern Inspection Methods Discussed in Worcester

F. J. Loomis, sales engineer, Bausch and Lomb Optical Company, presented a paper before the Worcester Section, Nov. 15, on the subject of modern inspection methods.

Junior Group Activities

Inspect Water Filtration Plant in Cleveland

On Saturday, Nov. 5, a group of Junior members of the Cleveland Section learned something about the operation of a metropolitan city's water supply in an inspection trip through the Baldwin filtration plant and the Kirtland pumping station. The first plant is equipped to filter, cleanse, and purify 165 million gallons of water every 24 hours, while the latter draws the water from a crib located five miles out in Lake Erie.

Junior Group Organized in New Orleans

Much interest was aroused in New Orleans among the Junior members by a letter sent out by J. K. Mayer, P. R. Roehn, and J. R. Rombach, members of the Membership Committee, in which the Committee asks: How many A.S.M.E. meetings have you attended and had the feeling that you were "left out" because the affairs of the Section were handled by older men? Also, how many meetings have you missed because you thought that there would be nothing of interest for you?

Then the letter goes on to invite all interested Junior members to attend an organization meeting on Oct. 26. K. P. Kammer, Chairman of the New Orleans Section, and J. M. Todd, vice-president of the Society, are listed as the chief speakers.

Philadelphia Juniors Practice Public Speaking

The first meeting of the year, with Bob Knipe presiding as chairman, featured Joseph G. Jackson, former Dale Carnegie student, who gave a very interesting talk on "The Engineer's Approach to Effective Speaking." Following his talk, everyone at the meeting was requested to get up and introduce himself to the audience. This proved fruitful in not only giving each man present a chance to practice his public speaking but also helped to make him feel at home.

W. W. LAWRENCE, CHAIRMAN OF JUNIOR MEMBERS' COMMITTEE ARRANGING ALL-MEMBERS' DINNER FOR DEC. 5

San Francisco Junior Group Holds Successful Meetings

Attendance at the September and October meetings more than fulfilled expectations, according to the San Francisco Junior Group's reporter, Marion B. Hughes. The first meeting, held Sept. 18, featured C. Ward Hahir, who spoke on "Practical Machine-Design Problems." Edwin C. Floyd, chairman of the Junior Group, and Geo. G. Sullivan introduced the topic of "Management Problems" at a seminar session held Oct. 20.

Interest in these meetings was evidenced by the caliber of the discussion. Junior members added much to each session by their questions and contributions to the general discussions.

MAIN THOROUGHFARE IN BIRMINGHAM

(A day's stopover will be made in Birmingham on A.S.M.E. tour to New Orleans.)

With the Student Branches

Student Branches in New York City to Hold Convention Prior to Annual Meeting

Students Will Be Guests of Stevens Branch at Hoboken, N. J., December 2

STEVENS BRANCH will act as host to the other Student Branches in New York and vicinity at Castle Point, Hoboken, N. J., on Friday evening, December 2, prior to the opening of the 1938 Annual Meeting of The American Society of Mechanical Engineers in New York, December 5. After a dinner, the convention of student members will be addressed by Dr. Harvey N. Davis, President of the Society and of Stevens Institute of Technology.

Then Prof. Kenneth Davidson, director of the Stevens experimental towing-tank laboratory, will show motion pictures and demonstrate models of hulls in the tank. He will explain how he helped to design the *Ranger*, the winner of the America's Cup, and other famous boats. Another speaker will be Prof. Harold Burris-Meyer, director of the Stevens Theater and the Short Hills Papermill Playhouse, who intends to talk on and give a demonstration of the work of the theater.

Following the talks, visitors will be conducted through the various laboratories. The working display in the mechanical-engineering laboratory will include the "knock engine." In the Stevens Museum, several of the early automobiles and machines will be demonstrated.

About Other Branches

Armour Visits Diesel Plant

ARMOUR BRANCH arranged an inspection trip for senior mechanical-engineering students to the Electromotive Corporation, the Diesel-engine division of General Motors at La Grange, Ill. After going through the plant, the visitors were shown a movie which described the construction of two-cycle Diesel engines. According to plans formulated by the officers of the Branch, every student member will be given an opportunity to give a paper at one of the meetings in order to train him in the essentials of public speaking.

ARKANSAS BRANCH at its meeting of Oct. 7, heard a talk on "The Manufacture of Rubber Tires" by Mr. McLain, instructor in chemistry.

ARIZONA BRANCH members had a unique experience when they were given the opportunity on Oct. 19 to inspect a dismantled steam unit of the local public-utility company. The rotor of the turbine had thrown a blade and everything, including the boiler, cooling tower, and feed pumps, was open for repairs.

Brooklyn Poly Has Surplus

Great was the rejoicing at a meeting of

BROOKLYN POLY BRANCH when Prof. F. W. Ming announced a surplus of $9.40 from last year in the Branch's treasury. However, the hard-working officers, led by C. Hollweg, are not letting this deter them from their goal of enrolling at least 120 members this year.

CALIFORNIA TECH BRANCH held a joint inspection trip with the A.I.E.E. student members on October 15 to the Long Beach steam station of the Southern California Edison Company. According to Charles Carstarphen, secretary, the trip was supplemented by a dip in the briny deep.

Timoshenko at Stanford

The main speaker of the October 13 meeting of CALIFORNIA BRANCH was Prof. Stephen Timoshenko, member A.S.M.E. He spoke on various laboratories of Europe and illustrated his talk with slides about the operation of different types of instruments for testing materials. In his report of the meeting, David T. Dobbins says that together with his Russian accent and his pleasing personality, Professor Timoshenko made a usually dry subject very interesting.

Social Studies at Carnegie

Dr. Willard E. Hotchkiss, former president of ARMOUR INSTITUTE and an expert in industrial management, has been appointed Maurice Falk Professor of Social Relations at the CARNEGIE INSTITUTE OF TECHNOLOGY. Assuming his duties late in September, Dr. Hotchkiss organized a new program of social studies for engineering students, thus getting under way an educational project which has been planned by President Robert E. Doherty for many years.

CATHOLIC UNIVERSITY BRANCH members at their first meeting on Oct. 18 voted to hold future meetings in the evening at 7:30 p.m. the first Wednesday of every month.

CLEMSON BRANCH had its first meeting on Oct. 10 opened with a few words of welcome by C. A. Dewey, Jr., chairman of the Branch.

C.C.N.Y. BRANCH had F. V. Erickson, Carrier Corporation, speak at its meeting of October 20 on "Power and Water Requirements in Air Conditioning."

Colorado Enlarging M.E. Facilities

Introduced by vice-chairman Fuller of the COLORADO BRANCH, Prof. S. L. Simmering, member A.S.M.E., talked on Oct. 5 about the reorganization and enlargement of the mechanical-engineering department at the University. He stated that a new addition will be added to engine building no. 2 and extensive improvements are expected to be made in existing laboratories, including the installation of an air-conditioning system.

COLORADO STATE BRANCH heard Dean Christenson on the subject of flood control in California.

Cornell Member Talks About Coulee Dam

Dana B. Waring, student member of the CORNELL BRANCH, was the speaker of the Oct. 11 meeting. His paper on "The Coulee Dam" was written after a trip to the West Coast last summer. In it he discussed the various engineering problems encountered in the construction of the dam and the methods used in solving them. Pictures taken by Mr. Waring and shown during the presentation of his paper added materially to the interest of his talk.

A.S.M.E. MARQUETTE BRANCH MEMBERS SELL FLOWERS TO AID NEEDY STUDENTS

DREXEL TECH BRANCH opened its first meeting with an attendance of 80, the largest turnout of students in recent years. C. C. Franck, design engineer of the Westinghouse South Philadelphia turbine shops addressed the group on the subject of "Modern Steam-Turbine Design." Several days later, the Branch made its first inspection trip of the season to the shops of Mr. Franck's company to look over some of the machines described at the meeting.

FLORIDA BRANCH heard a talk on airplane maintenance and overhaul by Mr. Tunis, a student member, who has had several years experience with Pan American Airways in this type of work.

Illinois Now Has 115 Members

According to a report given at the meeting of Oct. 12 by J. R. Poyser, chairman of the ILLINOIS BRANCH, 115 members have been enrolled so far this year. Following this, W. J. MacPherson, an industrial-relations expert, talked on "The Work of Engineers in Utilities." In his paper, he stressed the fact that above a salary range of about $200 per month, an engineer's advancement no longer depends upon his technical ability but upon his ability to deal with people. Therefore, it is important that student engineers should study and practice the art of getting along with people.

IOWA BRANCH at its meeting of Oct. 12 had Frederick E. Smith present a paper on "Railway Signaling;" R. John Box spoke on "What Every Engineer Should Know About Public Speaking;" and George G. Brunskill discussed the "Decentralization of Industry."

IOWA STATE COLLEGE BRANCH had 108 members and guests present at the meeting of Oct. 26. John Keller gave a short talk on turbine wheels and blading. At the close of the session, 14 new members were admitted to membership.

IOWA STATE UNIVERSITY recommends most highly the sound and technicolor motion picture by the United States Steel Corporation entitled, "Steel—Man's Servant," which was shown to the members of that Branch on Oct. 19.

Johns Hopkins Students Coming to Annual Meeting

Plans are being made by the JOHNS HOPKINS BRANCH seniors to attend the 1938 Annual Meeting of the A.S.M.E. in New York to see their beloved Prof. A. G. Christie inducted as 1939 President of the Society.

KENTUCKY BRANCH heard John L. Cutler of the English department speak on "The Value of English to Engineers," at the weekly meeting on Oct. 14. The following week, Prof. C. C. Jett had the pleasure of presenting a copy of Kent's Handbook, purchased with the Branch's library fund, to the officers of the Branch for the use of the members.

LAFAYETTE BRANCH at a meeting on Oct. 26 heard its honorary chairman, W. E. Reaser, speak on "Combustion Control in the Cement Industry."

LEHIGH BRANCH had R. A. Miller of the Pittsburgh Plate Glass Co. present a paper on "Structural Glass," which he illustrated with a series of films in which plant operations as well as the various manufacturing processes were shown.

200 at Lewis Meeting

About 200 students attended the meeting of the LEWIS BRANCH on Nov. 2 at which A. M. Unger, welding engineer with the Pullman Standard Car Manufacturing Co. showed two films, "Fabrication of Passenger Cars by Welding," and "Freight Car Construction by Welding." All the scenes shown were taken of actual production processes.

LOUISIANA STATE BRANCH members made an inspection trip to the mines and plant of the Freeport Sulphur Company at Port Sulphur, La., on Nov. 12.

LOUISVILLE BRANCH members heard talks by McKercher on "Superimposed Turbines," by Ayre on "Management's Aims and Responsi-

STUDENT OFFICERS OF PURDUE UNIVERSITY BRANCH OF THE A.S.M.E.

(Left to right: W. B. Wolverton, Jr., vice-president; R. Aldag, Jr., secretary-treasurer; C. E. Clutter, president; D. W. Herr, vice-president, in charge of membership; J. D. Bowen, vice-president in charge of programs. The decorations are, we think, cardboard.)

bilities," and by Wener on "Trends in the Design of Racing Airplanes."

MARQUETTE BRANCH had a lecture on "Infrared Photography," by Mr. Mossopust at its first meeting on Oct. 14.

70 Per Cent of Graduates Become Sales Engineers

MARYLAND BRANCH members on Oct. 26 heard C. J. Copley, The Socony-Vacuum Co., begin his talk on "Bearings and Their Lubrication," with the assertion that of those present, 10 per cent would find their life's work in design, 10 per cent in plant operation, 10 per cent in management, and 70 per cent in sales work. According to Robert J. Lodge, our capable reporter, the junior students set a precedent by bringing their "dates" to the meeting.

MICHIGAN BRANCH at its meeting of Oct. 19 had Dr. B. Curtis of the physics department talk on the construction, operation, and applications of the cyclotron which was just built by the University. Although the subject was somewhat removed from the field of mechanical engineering, it proved to be interesting and instructive to the audience of 70 members and guests.

MICHIGAN STATE BRANCH members made a trip to the General Motors Proving Grounds on October 25. During October, the following student members presented papers: M. J. Groat, Don Huffman, David James, Arnold Johnson, H. S. Keller, Arthur Kerkau, Charles Kilburn, Russel Lloyd, John Macomber, J. S. Blunt, H. D. Chicoine, R. C. Clough, W. R. Clow, Henry Cohn, Charles Gladden, D. C. Bender, A. F. Booth, D. W. Boyd, and Victor C. Carlson, who is doing such a good job as corresponding secretary.

MISSOURI BRANCH chairman, John Thurlo, appointed Irwin Trowbridge chairman of the program committee for the coming year. Irwin promises to provide meetings which will not only be interesting but also educational.

Prizes to Speakers at Montana State

At the first meeting of the year on Oct. 6, the members of MONTANA BRANCH decided that juniors would give their talks during the fall in competition for a book prize, the seniors would compete in the winter for the honor of presenting their papers at the 1939 Student Group Meeting, and the freshmen and sophomores will give papers in the spring in competition for a prize to be decided upon later.

NEVADA BRANCH had the following papers presented by student members during October: "Explosives Used in Engineering," by Gerald McCormack, "Mining Machinery," by Albert Atkinson, and "Traffic Control," by William Mitchell.

NEWARK COLLEGE BRANCH at its air-conditioning meeting on Oct. 3 had as speaker, Robert Ward, consulting engineer. In his ably presented talk, Mr. Ward outlined both the history and the fundamentals of the air-conditioning industry.

NEW MEXICO BRANCH has received an application for membership from a young woman student in the mechanical-engineering department. At the meeting on Oct. 3, Neal Draper presented a paper on the "Welding of Ferrous metals."

NORTH CAROLINA STATE members and guests at the meeting on Oct. 4 heard Dean Blake Van Leer give a short talk on the advantages of membership in the Branch.

North Dakota to Build Float

At a special meeting on Oct. 27, it was decided by the members of NORTH DAKOTA STATE BRANCH to build a float for the homecoming parade. Harvey Boe, Lancelot Montgomery, and Arthur Hewett were appointed to the Float Committee by Kaare Loftheim, who is the newly elected chairman of the Branch.

NORTH DAKOTA BRANCH members at their meeting on Oct. 13 heard Prof. Alexis Diakoff give an inspiring address on the importance of the A.S.M.E. to students and engineers.

NOTRE DAME BRANCH at its meeting of Oct. 4 had Robert Dieckelman give a paper on air conditioning. An inspection trip was made a few days later to the Studebaker automobile plant in South Bend, Ind.

Ohio State Offers New Welding Course

A new curriculum in OHIO STATE UNIVERSITY'S College of Engineering leading to a degree in welding engineering was announced early in October. Entrance requirements are the same as for the other curricula and admissions will be in the hands of the entrance board at Ohio State, to which inquiries should be directed.

OKLAHOMA BRANCH obtained Rex Morgan, Phillips Oil Co., for a talk on "The Absorption System in the Manufacture of Natural Gasoline," which was given on Oct. 26. On Oct. 29, fifty members heard R. W. Robson, chief engineer of the Carter Oil Co. discuss "Engineering in Oil."

PENNSYLVANIA BRANCH members had the pleasure of listening to a talk on lubrication by C. J. Copley, Socony-Vacuum Oil Co.

Kenneth Condit Talks at Pratt Institute

Kenneth Condit, vice-president of the Society, was the guest speaker at the Oct. 20 meeting of PRATT BRANCH. He reviewed the history of the parent organization, its operation, and the work of the many committees within it.

PRINCETON BRANCH at its meeting of Oct. 20 accepted the suggestion of Dean A. M. Greene about having one meeting a month devoted to a discussion of the articles in MECHANICAL ENGINEERING.

Rensselaer Builds and Operates Railroad

With the attendance at meetings ranging from 175 to 200, the RENSSELAER BRANCH is having a very active year. One of its activities this year has been the construction of a railway, including grading, track laying, and the building of a roundhouse, and the operation of a model locomotive of the American type. The general manager of the Rensselaer Central Railroad, as it is known, is Charles Culp.

RHODE ISLAND STATE BRANCH held an old-fashioned smoker on Oct. 26; ice cream, cake, and coffee were served and "talkies" shown to the audience which was composed of the entire student body of the engineering school.

RICE BRANCH, after a discussion on the Texas law for the registration of engineers by R. R. Crookston, honorary chairman, decided to send to the state capitol for further information.

U.S.C. BRANCH enrolled 25 old and new members at its first meeting.

SOUTHERN METHODIST BRANCH members were invited to attend the meetings of the North Texas Section of the A.S.M.E. by N. G. Hardy, chairman of the Section.

TENNESSEE BRANCH members met on Oct. 19 to see a motion picture entitled, "The Inside Story of Lubrication." After the showing, a general discussion was led by M. L. Booker of the Magnolia Oil Company.

Texas A. & M. Signs 100th Member

Under the active chairmanship of Jack Clark, TEXAS A. & M. BRANCH is really clicking now. K. W. Ryan had the distinction of being the hundredth member to sign up. Members

of the hard-working Program Committee are G. W. Staples, chairman, Alex Nordhaus, Buddy Mandell, W. T. Guy, R. C. Wade, Nate Snyder, T. M. Haygood, and Phil Potts.

TEXAS TECH BRANCH also showed the motion picture, "The Inside Story of Lubrication." Mr. Hull of the Magnolia Oil Company was the lecturer.

TEXAS BRANCH ran a meeting on Oct. 17 at which talks were given by students on the type of work they did during the summer. The speakers included D. D. Wilson, Ralph Powers, William Marsh, C. E. Simpson, and J. L. Malone.

UTAH BRANCH members elected Donald C. Worden to the vacant office of vice-chairman.

VERMONT BRANCH visited the printing plant of the *Burlington Free Press* on Oct. 14. At the meeting on Oct. 21, Bernard Hill gave a paper on his work during the summer with the Stanley tool people in Shaftsbury, Vt.

V.P.I. Meets With Virginia Section

With 100 student members and 50 members of the Virginia Section A.S.M.E. present, V.P.I. BRANCH presented a program of student speakers at a joint meeting held on Oct. 29. G. T. Jones and H. S. Miles gave a paper on traffic control entitled, "Distance and Time Required for Passing Vehicles." P. D. Dale talked on high-speed photography, illustrating with a color film furnished through the courtesy of the Eastman Kodak Company.

VIRGINIA BRANCH heard all about the Philadelphia trip of the members last year in a talk given by John Owen.

WASHINGTON BRANCH at its meeting of Oct. 20 had Prof. F. S. Eastman of the aeronautical-engineering department give a talk on the University's wind tunnel.

W.P.I. Plans Building

Admiral Ralph Earle, president of WORCESTER POLYTECHNIC INSTITUTE, was authorized at the fall meeting of the college board of trustees on Oct. 22 to place in the hands of architects sketches for a new mechanical-engineering building, the second step in a three-point W.P.I. building program. A new wing for the Salisbury Laboratories is now under construction. When the new building is finished late next year, the present mechanical-engineering building will be turned over to the civil-engineering department.

YALE BRANCH, according to J. L. Meriam, Jr., secretary, has planned a schedule for this year which includes active participation by the junior students in meetings, a series of evening programs consisting of demonstrations and lectures, motion pictures on engineering subjects, inspection trips to manufacturing plants, and talks by student members and members of the faculty on a variety of subjects.

Photoelasticity Meeting New York City, Dec. 10

THE eighth semi-annual meeting of the Eastern Photoelasticity Conference will be held on Dec. 10, 1938, at Columbia University, New York City. A symposium on three-dimensional photoelasticity is planned.

John Fritz Medal Awarded to Frank Baldwin Jewett

Medal Board Becomes a Committee of United Engineering Trustees, Inc.

FRANK BALDWIN JEWETT was elected unanimously as the recipient of the 1939 John Fritz Medal "for vision and leadership in science, and for notable achievement in the furtherance of industrial research and development in communication," according to an announcement made at the annual meeting of the John Fritz Medal Board of Award on Oct. 21, 1938. It is expected that the presentation of the award to Dr. Jewett will be made at the annual meeting of the A.I.E.E. in New York, Jan. 23–27, 1939.

The following were admitted as members of the Board: Henry E. Riggs, A.S.C.E., Daniel C. Jackling, A.I.M.E., Harvey N. Davis, A.S.M.E., and John C. Parker, A.I.E.E. Other A.S.M.E. members on the Board include Ralph E. Flanders, William L. Batt, and James H. Herron. Mr. Batt was elected chairman for 1938–1939.

It was also announced at the meeting that The John Fritz Medal Fund Corporation was dissolved on Aug. 8, 1938, on advice of counsel. The chairman was therefore empowered so to inform United Engineering Trustees, Inc., and to petition it to accept the Medal Board of Award as a committee of the Corporation. This petition was duly presented to U.E.T. at the meeting on Oct. 27, 1938, and the Board accepted as a Committee of the Corporation.

American Engineering Council Third Public Forum

January 12–14, 1939 Washington, D. C.

THE 19TH Annual Assembly of the American Engineering Council will convene in Washington at the Hotel Mayflower Jan. 12, 13, and 14, 1939. The first four sessions of the Assembly held on Thursday morning and afternoon and Friday morning and afternoon, will be conducted as the Third Forum of American Engineering Council, on a series of public questions under the leadership of committees of the Council. The fifth session—the Annual All Engineers' Dinner—will be held on Friday evening. The business session of Council will be conducted as the sixth session of the Assembly on Saturday morning, January 14.

Under the direction of the President, the Executive Committee, and the Committees on Public Affairs, a series of topics with leaders of discussion is being developed. These topics include "The Economic Status of the Engineer," which will be under the direction of the Committee on Economic Status; "Engineering Factors in the Size of Business," under the direction of the Committee on Engineering Economics; "Public and Private Construction and the Engineers' Relation to Them," under the direction of the Public Works Committee; "National Planning and the Engineers' Relation to It," under the direction of the Public Affairs Committee.

Engineering Examiners Meet in Des Moines, Oct. 17–18

C. F. Scott, Member A.S.M.E., Elected President for 1939

THE NINETEENTH annual convention of the National Council of State Boards of Engineering Examiners was held in Des Moines, Iowa, Oct. 17 and 18, and was attended by delegates from 26 states and representatives of several national engineering societies. The A.S.M.E. official delegates included the retiring president, Prof. S. H. Graf, the newly elected president, Dr. Charles F. Scott, and Virgil M. Palmer. Other new officers elected were Col. A. C. Polk, vice-president; Prof. J. H. Dorroh and F. E. Rightor, directors.

It was reported that the next annual meeting of the Council will be held in San Francisco in July, 1939, and that during the last year Rhode Island and Kentucky adopted engineering registration laws, and are now members of the Council, which is now composed of 40 member boards in 38 states, Hawaii, and Puerto Rico, representing a total of approximately 60,000 registered professional engineers and land surveyors.

The following resolution was adopted: "That it be the consensus of the members of the National Council of State Boards of Engineering Examiners that this Council is an advisory and coordinating agency established primarily to assist the State Boards of Registration for Professional Engineers in a more efficient and uniform administration of state registration laws, and that its functions and activities include the certification of engineers, jointly with State Boards, for reciprocal registration in the various states, and the operation of a national clearing house and information bureau for matters pertaining to the legal registration of professional engineers, serving State Boards, state committees, engineering societies, individual engineers, and the public.

The E.C.P.D. Issues List of Accredited Undergraduate Curricula for 1938

A LIST of accredited undergraduate curricula for 1938 was issued on Oct. 28, 1938, by the Engineers' Council for Professional Development, which represents the A.S.C.E., A.I.M.E., A.S.M.E., A.I.E.E., A.I.Ch.E., S.P.E.E., and the N.C.S.B.E.E. This list, which accompanies the sixth annual report of the Council, includes only such undergraduate engineering curricula as have been judged by E.C.P.D. to be worthy of accrediting. It does not include certain specialized curricula sub-

mitted for consideration, which, though apparently outstanding in restricted fields, are not closely related to engineering as it is interpreted by the Council.

The present list, dating from Oct. 22, 1938, will again be subject to revision in the fall of 1939. It replaces the first partial list which was released for publication in October of 1936, and the succeeding list, dated Oct. 1, 1937, published in full in MECHANICAL ENGINEERING for December, 1937.

Engineering Foundation Officers for 1938–1939

OFFICERS and members of the board and committees for the fiscal year, Oct. 1, 1938, to Sept. 30, 1939, have been announced by The Engineering Foundation, a department of United Engineering Trustees, Inc. F. M. Farmer, vice-president and chief engineer, Electrical Testing Laboratories, New York, N. Y., remains as chairman, and Otis E. Hovey, member A.S.M.E., and John H. R. Arms, member A.S.M.E., are continued as director and secretary, respectively. George E. Beggs, professor of civil engineering, Princeton University, becomes vice-chairman of the Foundation.

A.S.M.E. representatives on the Foundation Board are Kenneth H. Condit, elected by the Board of Trustees, United Engineering Trustees, Inc., and W. H. Fulweiler, and Albert E. White, nominated by the Council of the A.S.M.E. Edwards R. Fish is one of the three members-at-large and represents the A.S.M.E. Kenneth H. Condit is a member of the Foundation executive committee and represents the Foundation on the Research Procedure Committee, on which Mr. Fulweiler is the A.S.M.E. representative.

E.C.P.D. Elects Officers

J. P. H. Perry Assumes Duties of Chairman

AT ITS 1938 annual meeting, held in New York on October 21 and 22, the Engineers' Council for Professional Development elected J. P. H. Perry, of New York, chairman for the coming year. R. E. Doherty, president, Carnegie Institute of Technology, Pittsburgh, Pa., was elected vice-chairman. S. L. Tyler, secretary of the American Institute of Chemical Engineers, New York, takes office as secretary, and C. E. Davies, Secretary of The American Society of Mechanical Engineers, continues as assistant secretary of E.C.P.D.

As chairmen of the four principal committees, the following selections were made: Committee on Student Selection and Guidance, R. L. Sackett; Committee on Engineering Schools, Karl T. Compton; Committee on Professional Training, O. W. Eshbach; and Committee on Professional Recognition, C. F. Scott.

New members of the four committees are the following: Student Selection and Guidance, M. M. Boring and H. O. Croft; Engineering Schools, A. A. Potter (reappointment) and A. B. Newman; Professional Training, E. Warren Bowden and Frank L. Eidmann; Professional Recognition, C. F. Scott and D. C. Jackson.

A.S.M.E. Member Wins Almost $14,000 in Arc-Welding Contest

A. E. GIBSON, member A.S.M.E., and president, The Wellman Engineering Co., Cleveland, Ohio, and his wife, won the grand award of $13,941.33 in the James F. Lincoln Arc Welding Foundation's contest. Other A.S.M.E. members who won include Robert E. Kinkead $8852.94, C. A. Davis, Jr. $1729.84, and Hamilton Johnson $305.26. Judged by a jury of 31 engineering authorities, the papers submitted by contestants showed a saving of $1,600,000,000 available to industry by wider application of the arc-welding process.

Contractors Ask Engineers For Larger Drawings

AT ITS 49th annual convention, the National Association of Heating, Piping, and Air Conditioning Contractors adopted the following resolution for the elimination of small-scale drawings:

WHEREAS: The furnishing of small-scale drawings and specifications and insufficient information necessary to intelligently prepare an estimate has caused serious loss to the members of this industry; therefore, be it

Resolved: That it is recommended that proper plans and specifications shall be furnished for the preparation of a bid showing and describing all the work to be bid upon. It is further recommended that no plans, except block plans, shall be drawn to a scale less than one-eighth inch to the foot. When one-eighth inch scale plans fail to adequately show or describe the work it recommended that larger scale drawings shall be provided to indicate the requirements.

A.S.A. Representative in Buenos Aires, S. A.

THE Board of Directors of the American Standards Association recently took favorable action on a proposal that a permanent staff representative be stationed in Buenos Aires, Argentina, S. A., for the purpose of promoting American Standards and other standards now in use by American industry. Decision of the Board to do this was based largely on the recommendations of a group of manufacturing concerns, trade associations, and technical societies that met last June to discuss the need of a better knowledge of American industrial standards in South America. The fact that British, German, and other interests have for some time been active in encouraging adoption of their standards had already brought forth suggestions from the U. S. Chamber of Commerce at Buenos Aires that American interests should also be represented.

Local Sections

Coming Meetings

Anthracite Lehigh Valley: January 27. Scranton, Pa. at 8:00 p.m. The subject of this meeting will be "Welding," and will be a joint meeting with the American Welding Society.

Baltimore: December meeting (exact date not yet selected). Merchants Club, Baltimore, Md. Testimonial Dinner in honor of Professor A. G. Christie, president-elect of the A.S.M.E.

Chicago: December 6. Meeting to be sponsored by the Manufacturing division of the Section. Subject: "Machinery Purchasing," by R. S. Perry, vice-president Ingersoll Milling Machine Co.

During second week of December under sponsorship of power and fuels division of Section. Subject: "Heat-Balance Method of Boiler Testing," by E. L. McDonald who is a member of Power Test Code Subcommittee, No. 4.

December 20: Junior Group of Section to be hosts of Student Branches from Northwestern, Armour, and Lewis. Symposium will be presented on "The Profession of Mechanical Engineering."

Erie: December 8. Meeting to be held at the Pennsylvania Telephone Corporation Auditorium, Erie, Pa. Subject: "Loxology," by Maxwell C. Maxwell of the Yale & Towne Manufacturing Company, New York, N. Y.

Florida: December 3. Joint meeting of the Florida Section and the University of Florida Student Branch. Technical sessions at P. K. Yonge School Auditorium. From 9:30–12 noon: paper by T. H. Gardner, St. Augustine, "Bridge Welding." Mr. Gardner is a prize winner in the James F. Lincoln Arc Welding Contest. Luncheon meeting, University Cafeteria, 12:30–1:30 p.m. Meeting of Executive Committee, 207 Engineering Building, 1:30–2:00 p.m. Football game at Florida Field at which Temple University Owls will play the Florida Fighting Gators, 2:30 p.m.

Knoxville: December 2. University of Tennessee Cafeteria at 6:30 p.m. Subject: "Sulphur: Its Occurrences and Sulphur Mining," by James M. Todd, consulting engineer of New Orleans, La., and vice-president of the Society.

North Texas: December 12. Texas Electric Service Auditorium, Fort Worth, Texas, at 8:00 p.m. Subject: "Water Life in Texas," illustrated lecture by Major John B. Hawley, consulting engineer of Hawley, Freese & Nichols, Fort Worth, Texas.

Pittsburgh: December 6. Cardinal Room, William Penn Hotel, Pittsburgh, Pa. at 8:00 p.m. Subject: "Fiber Glass," by L. R. Yeager, chief engineer, Products Analysis Department, Industry and Structural Laboratory of Owens-Illinois Glass Co., Newark, Ohio. There will be a film and demonstration to supplement this talk.

Rock River Valley: December 1. Hilton

(*Continued on page 1000*)

Photo Courtesy Boston Gear Works, Inc.

Studying Speed

THIS high-speed grinder is turning at 10,400 rpm yet with the STROBOTAC it appears to be absolutely motionless. Its speed can be checked with the STROBOTAC to an accuracy within 2 per cent between 600 and 72,000 rpm. More important, the grinder can be made to appear to rotate very slowly (less than a single rpm) so that the cutting angle, grinding edge and the surface of the helical gear can be observed while the grinder is operating at its normal speed of 10,400 rpm.

The STROBOTAC throws a beam of stroboscopic light, the flashing rate of which can be synchronized with any periodic rotating or reciprocating machine or part to 'stop' motion. When adjusted slightly off synchronism, slow-speed observation of high speed machinery is possible.

The applications of the STROBOTAC in industry have proven to be limitless. It is an extremely valuable tool in the hands of research, design, maintenance and sales men. If you have any problem involving the study of motion, the STROBOTAC can help you.

WRITE FOR BULLETIN 337

for complete details of this and other stroboscopic instruments, designed by Messrs. Edgerton, Germeshausen and Grier of M.I.T. and manufactured and sold by General Radio Company

TYPE 631-A STROBOTAC $95.00

GENERAL RADIO COMPANY

Cambridge, Massachusetts

Branches: New York • Los Angeles

Hotel, Beloit, Wis., at 7:00 p.m. Subject: "Elimination of Noise," by Dr. Ernest J. Abbott, President, Physicist Research Company, Ann Arbor, Mich. By means of demonstrations with ultramodern instruments as well as with actual case histories the speaker will develop the precise technique of quieting noise at its source in many different types of machinery.

December 13. Rockford, Ill. Subject: "The Manufacture of High-Speed Tanks," by Major John K. Christmas, Office of the Chief of Ordnance, Washington, D. C.

San Francisco: December 1. Engineers' Club, 206 Sansome St., San Francisco, Calif. Dinner at 6:00 p.m., meeting at 7:30 p.m. Subject: "Materials-Handling Equipment and Methods," by J. F. Strott, engineer, Link Belt Company, San Francisco, Calif.

January 12. Subject: "Modern Developments in Aircraft." This meeting will be sponsored by the National Defense Group.

Men and Positions Available

Engineering Societies Employment Service

MEN AVAILABLE[1]

MANUFACTURING EXECUTIVE; varied experience managerial and supervisory capacity; accustomed to all phases of factory administration, production, design, plant layout, purchase, foundry and forge shop along various lines; best of references. Me-187.

MOLDING ENGINEER, graduate, 36, single. Wide experience design and production, molding, mechanical, and electrical fields. Creative and organizing ability. Now in responsible position with plastic firm. Desires change and real opportunity. Me-188-387-D-1-San Francisco.

MECHANICAL ENGINEER, [illegible]ire, widely experienced machine designer and draftsman. Twelve years on the board, good checker. College graduate in mechanical engineering. Experience at machinist's trade in repair shop. Me-189.

ENGINEERING EXECUTIVE, 52, graduate Cornell, M.E., M.M.E. Twenty-nine years engineering experience covering design, manufacturing and sales for variety of products in electrical, automotive, machine-tool, and agricultural-machinery fields. Location immaterial. Me-190.

MECHANICAL ENGINEER, 1938 graduate, age 22, single. Specialized in aeronautics, steam, gas power, engineering economics. Varied industrial summer experience. Desires opportunity in field of training. Middle West preferred. Me-191.

EXECUTIVE-ENGINEER, age 38, married. Six years' experience in Philippines in sales, design, and construction. Foreign connection desired. Speaks Spanish. Import, export knowledge. Broad electrical and mechanical background. Excellent references. Me-192.

EXECUTIVE MECHANICAL ENGINEER, graduate, married. Practical manufacturing background. Broad business experience. Managerial capacities, design, sales, contracting, fabricating sheet-metal installations, blowers, fans, heating, ventilating, dust-collecting, drying, blast, exhaust systems. Me-193.

MECHANICAL ENGINEER, graduate, age 39. Eleven years' tool and machine designing; 11 years' executive experience in experimental development work on machinery. Me-194.

GRADUATE MECHANICAL ENGINEER, Harvard, 1924, with broad industrial experience, seeks development position in oil-burning, air-conditioning, refrigeration, or allied lines. Me-195.

MECHANICAL ENGINEER, 1938 graduate, age 23, single, member Sigma Nu. Experienced in drafting, heating and air-conditioning design, and general machine design. Interested in aviation and air-conditioning fields. Location unimportant. Me-196.

WANTED, AN OPPORTUNITY to study company's manufacturing methods, as methods engineer, to improve quality and lower costs with an opportunity of eventual advancement to executive position. Me-197.

MECHANICAL ENGINEER, graduate Villanova, 1938. Experience in shop maintenance and machinery installation, gas welding. Good mechanic. Wants position in production department, sales engineering, maintenance. Will travel. Me-198.

GRADUATE MECHANICAL ENGINEER, 25. Four and one-half years' experience in light and heavy airplane construction, machine shop, maintenance, and time and motion study. Location preferred in East. Me-199.

ASSISTANT TO CONSULTING ENGINEER, 32, single. Twelve years' experience on power, mechanical, and electrical installations in industrials and institutions; on reports, design, specifications, and contacting clients. Desires change. Location immaterial. Me-200.

MECHANICAL ENGINEER, long experience in sales engineering: Diesel engines, pumps, variable-speed drives, centrifugal separators for entrained liquids, dust collectors for hot and cold gasses, automatic controls for industrial oil burners. Me-201.

CHIEF DRAFTSMAN, 31, married. Six years' oil-refinery design and construction. Also experienced in Diesel engine. Knows materials and equipment in oil refinery. Natural leader. Congenial. Available immediately. Me-202.

SALES ENGINEER, graduate mechanical engineer, wide training in large manufacturing plant, experienced domestic, export sales industrial and railway equipment, familiar dealer specialty selling, offers services for New York metropolitan area. Me-203.

MECHANICAL ENGINEER, 24, recent graduate. Experience in water-pollution surveys and sanitation work. Also some light machine-shop experience. Desires connection in internal-combustion engine field or allied industry. Me-204.

DEVELOPMENT EXECUTIVE ENGINEER, broad experience. Has native creative inventive ability and patent-law knowledge with resourcefulness and initiative; seeks position supervising design of machinery, products and plant processes of manufacture. Me-205.

POSITIONS AVAILABLE

INDUSTRIAL ENGINEER with 8 to 10 years' experience. Must be able to set time standards and install wage incentive in plant now on daywork. Ability to improve layout of plant equipment and assist in installing standard costs is important. Experience in welding and machine shop would be desirable. Apply by letter. Location, Middle West. Y-3413-R-638C.

TEXTILE ENGINEER for industrial survey of textile plant. Must be experienced in processing and finishing rayon and silk. Salary, $60 week. Temporary, but may lead to permanent connection. Apply by letter. Location, Pennsylvania. Y-3417.

PURCHASING AGENT, 30–40, with an engineering background. Must have 5 to 10 years' experience in purchasing of general nature. Apply by letter. Location, New York, N. Y. Y-3418.

DESIGNER for centrifugal pumps. Must be well-experienced in design of axial-flow or propeller pumps, radial-flow side-suction and double-suction pumps and mixed-flow side-suction pumps. Apply by letter stating age, experience, education, and salary desired. Location, Middle West. Y-3419C.

GRADUATE MECHANICAL ENGINEER, 35–40, with 10 to 12 years' experience in central-station steam-power-plant work. Apply by letter. Location, New York State. Y-3422.

AUTOMOTIVE ENGINEER to take charge of manufacture and sale of line of automobile mufflers. Must have recent experience in muffler line, and must be thoroughly familiar with requirements, both replacement and original equipment. Salary, $3000–$5000 a year. Apply by letter. Location, Illinois. Y-3427-R-640C.

CONSTRUCTION ENGINEER, young, preferably of Swedish extraction, who is interested in adding machines. Man with experience in constructing ten-key adding machines preferred. Apply by letter giving age, qualifications, experience, etc. Location, Sweden. Y-3434.

DESIGNER to work on reciprocating air compressors and high-speed air compressors. Man with experience in similar machinery, not necessarily compressors but closely allied, preferred. Must be thoroughly familiar with mathematics and mechanics. Apply by letter. Location, Pennsylvania. Y-3439.

GRADUATE MECHANICAL ENGINEER, about 40, with exceptionally good experience in design and development of large machinery, subsequently attaining executive position of responsibility. Capable of contributing original ideas and designs, and organizing, managing department for this purpose. Should have earned at least $7500 a year for four or five

(Continued on page 1002)

[1] All men listed hold some form of A.S.M.E. membership.

Free!
5 FACT-PACKED HANDBOOKS
COR-TEN
WELDING INSTRUCTIONS and STANDARDS
PART I SYMBOLS and METHOD of SHOWING WELDING on DRAWINGS
The FABRICATION of U·S·S STAINLESS STEELS
PART 1 · Welding · Riveting Soldering and the Design of Joints
UNITED STATES STEEL
ROLLED STEEL
FOR MACHINE CONSTRUCTION
The WELDER'S HAND BOOK
PREMIER TESTED WELDING WIRE
AMERICAN STEEL & WIRE COMPANY

TO HELP YOU BUILD BETTER WITH ROLLED STEEL

• ROLLED STEEL FOR MACHINE CONSTRUCTION

Valuable information on fabricating better machinery at lower cost. Describes the use of Rolled Steel with flame cutting and welding. Answers your questions as to how weight is affected . . . what savings are possible . . . what types of steel are best suited. Includes suggestions on economies in buying. Explains modern shop practice.

• WELDING INSTRUCTIONS AND STANDARDS

Part I. Symbols and method of showing welding on drawings by the American Welding Society's new symbol method. An 82-page book, well illustrated with pictures and diagrams. A supplementary section contains valuable information on standard sections of welds, filler metal specifications, notes on the welding of high tensile steels, workmanship and annealing.

• THE WELDER'S HANDBOOK

A condensed manual on welding practice which gives helpful information on approved methods for both electric arc and gas welding and practical suggestions for the selection of electrodes, welding rods, etc.

• THE FABRICATION OF U·S·S STAINLESS STEELS

Part I. Welding, Riveting, Soldering and the Design of Joints. A 54-page, elaborately illustrated book. Describes the different types and distinguishing characteristics of the various stainless steels, shows how to weld them by each of the various methods, discusses annealing, the finishing of welds, removal of scale, pickling and joint design recommended.

• THE "COR-TEN" BOOK

68 pages, crammed full of facts, figures and original data on the use of this low-cost, high tensile steel that has put lightweight construction of mobile equipment on a truly self-liquidating basis. Tells where this high-strength, highly corrosion-resistant steel has reduced dead weight and increased payload capacity without loss of strength or safety. Shows how COR-TEN can be fabricated by ordinary shop methods, why it costs so little to use. Describes most economical and practical shop procedures.

• • •

BECAUSE THE SUPPLY IS LIMITED . . . We are forced to restrict the offer of these books to executives, designers, welders, purchasing agents only. Ask for copies you desire on your company letterhead and please indicate your company title.

AMERICAN STEEL & WIRE COMPANY, *Cleveland, Chicago and New York*
CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*

United States Steel Products Company, New York, *Export Distributors* · Scully Steel Products Company, Chicago, *Warehouse Distributors*

UNITED STATES STEEL

years. Apply by letter giving complete details of education and experience. Location, New York, N. Y. Y-3442.

MASTER MECHANIC, 35–45, to act as assistant to chief engineer. Must have wide range of experience in maintenance of process equipment and heavy machinery in large plants, and ability to organize and handle group of men. Will have under his supervision 125 mechanics. Salary, $4000–$5000 a year. Apply by letter. Location, Middle West. Y-3451-R-642C.

MECHANICAL ENGINEER, not over 45, to handle water-tube boiler division of company manufacturing various steel products. The boilers range in size to 100 hp and 600 lb pressure. Combinations of boilers, superheaters, waterwalls, air preheaters, and economizers to lay out, cost estimating, working out heat balances, and in general, carrying on business for company. Salary, $250 a month. Apply by letter. Location, Middle West. Y-3472-R-643C.

MECHANICAL ENGINEER thoroughly familiar with and capable of directing planning and scheduling department for producing long line of production materials. Must be able to fill orders promptly, with minimum amount of materials tied up in inventory. Only man thoroughly experienced in such work will be considered. Apply by letter. Location, Pennsylvania. Y-3489.

GRADUATE MECHANICAL ENGINEER, 35–50, to act as chief engineer for lime, cement, and mineral-wool company. Man well-versed in Portland-cement-mill design will be considered. Apply by letter. Location, South. Y-3496.

ASSOCIATE PROFESSOR, graduate mechanical engineer, 35–45, preferably with a master's degree, to teach mechanical engineering in eastern university. Should have some practical experience in addition to at least 5 years' teaching experience. Must be of Catholic faith. Apply by letter. Y-3498.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after December 27, 1938, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Reelection; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member

NEW APPLICATIONS

For Fellow

POWELL, S. T., Baltimore, Md.

For Member, Associate, or Junior

ACKERMAN, EDW. J., New York, N. Y.
ARTHUR, W. E., Wilmington, Calif.
BAJAJ, D. R., Bilaspur, C. P., India
BEALE, FRANK L., Oakmont, Pa.
BERRYMAN, JOHN H., Baltimore, Md. (Re)
BIRSS, R. J., Brampton, Ontario (Re)
BROGHAMER, EDW. L., Urbana, Ill.
BROWN, HUBERT L., Kansas City, Mo.
CASE, WILLARD LACY, New York, N. Y. (Rt)
DAWLEY, CHESTER GRANT, Boston, Mass. (Rt & T)
DEWEY, RAYMOND E., Shelby, Ohio
DOLENGO-KOZEROVSKY, W. P., Beechhurst, L. I., N. Y.
DUENNES, FRANK C., Oak Park, Ill.
ELLIOTT, CARROLL L., Austin, Minn.
FERRARI, FRANK A., Rochester, N. Y.
GABRIELSON, GUNNAR, Cleveland Heights, Ohio
GOODRICH, R. H., Indianapolis, Ind.
GORDOX, WILLIAM, Kew Gardens, L. I., N. Y. (Rt)
GRONEMEYER, FRED G., Longmeadow, Mass. (Rt & T)
HANDLER, CHARLES, Altavista, Va.
HANSCOM, G. L., S. Walpole, Mass.
HAWORTH, H. L., Richmond, Ind.
HELM, PAUL F., Indianapolis, Ind.
HILL, ARTHUR M., New Orleans, La. (Rt & T)
HONIGMAN, ELKONO, New York, N. Y. (Rt & T)
HOVEY, WALTER F., New York, N. Y. (Rt)
JOHNSON, JOHN A., Chicago, Ill.
JOHNSON, PAUL H., Indianapolis, Ind.
KAISER, FRANZ F., La Grange, Ill.
KAUTT, ELMER C., Syracuse, N. Y.
KEARNEY, FRANK V., New York, N. Y.
KLINGENSMITH, A. E., Indianapolis, Ind.
KNAEPPER, GEORGE B., Detroit, Mich.
KNECHT, HARRY, Newark, N. J.
LOUDON, DAVID S., Summit, N. J.
MARTIN, FRANK L., St. Louis, Mo.
MASON, F. C., Ft. Wayne, Ind.
MILLER, EDGAR B., Charleston, S. C.
ROTONDO, ALFRED, Methuen, Mass.
RUBIN, MAURICE L., New York, N. Y.
SALMA, EMANUEL A., New York, N. Y. (Re)
SCOFIELD, J. HARRY, Ft. Collins, Colo.
SEGELER, JOHN CALVIN, Chicago, Ill. (Rt & T)
SHUMAKER, CLIFFORD H., Dallas, Tex.
SKAREDOFF, NIKOLAI N., New York, N. Y.
SPANGLER, GEORGE F., Indianapolis, Ind.
TALBOTT, D. C., Indianapolis, Ind.
TRENT, CLARENCE E., Bluefield, Va. (Re)
WADMAN, REX W., New York, N. Y.
WEILER, HARRY E., JR., Chicago, Ill.
WHIPPLE, JOHN W., Balboa, Canal Zone
WILDE, F. G. WASHINSKY, New York, N. Y.

CHANGE OF GRADING

Transfer to Fellow

TIMOSHENKO, S., Stanford University, Calif.

Transfers to Member

ABDUN-NUR, E. A., Billings, Mont.
BARKER, GEORGE SANDS, Norristown, Pa.
BEYER, BEN W., JR., Detroit, Mich.
GRIMISON, E. DOUGLAS, Fanwood, N. J.
HAWKINS, GEORGE A., West Lafayette, Ind.
SARACINO, FRANK E., Chicago, Ill.
SPRING, H. M., JR., Boston, Mass.

A.S.M.E. Transactions for November, 1938

THE November, 1938, issue of the Transactions of the A.S.M.E. contains the following papers:

TECHNICAL PAPERS

Rotary Oil Meters of the Positive-Displacement and Current Types (PRO-60-3), by E. M. Cloran

Pressure-Responsive Elements (PRO-60-4), by P. G. Exline

Application of Temperature Controllers (PRO-60-5), by E. D. Haigler

Some Fundamental Considerations in the Application of Automatic Control to Continuous Processes (PRO-60-6), by E. S. Bristol and J. C. Peters

Application of Automatic Control in the Oil Industry (PRO-60-7), by D. J. Bergman

Pressure-Type Thermometer Systems (PRO-60-8), by L. G. Bean

Quantitative Analysis of Single-Capacity Processes (PRO-60-9), by A. F. Spitzglass

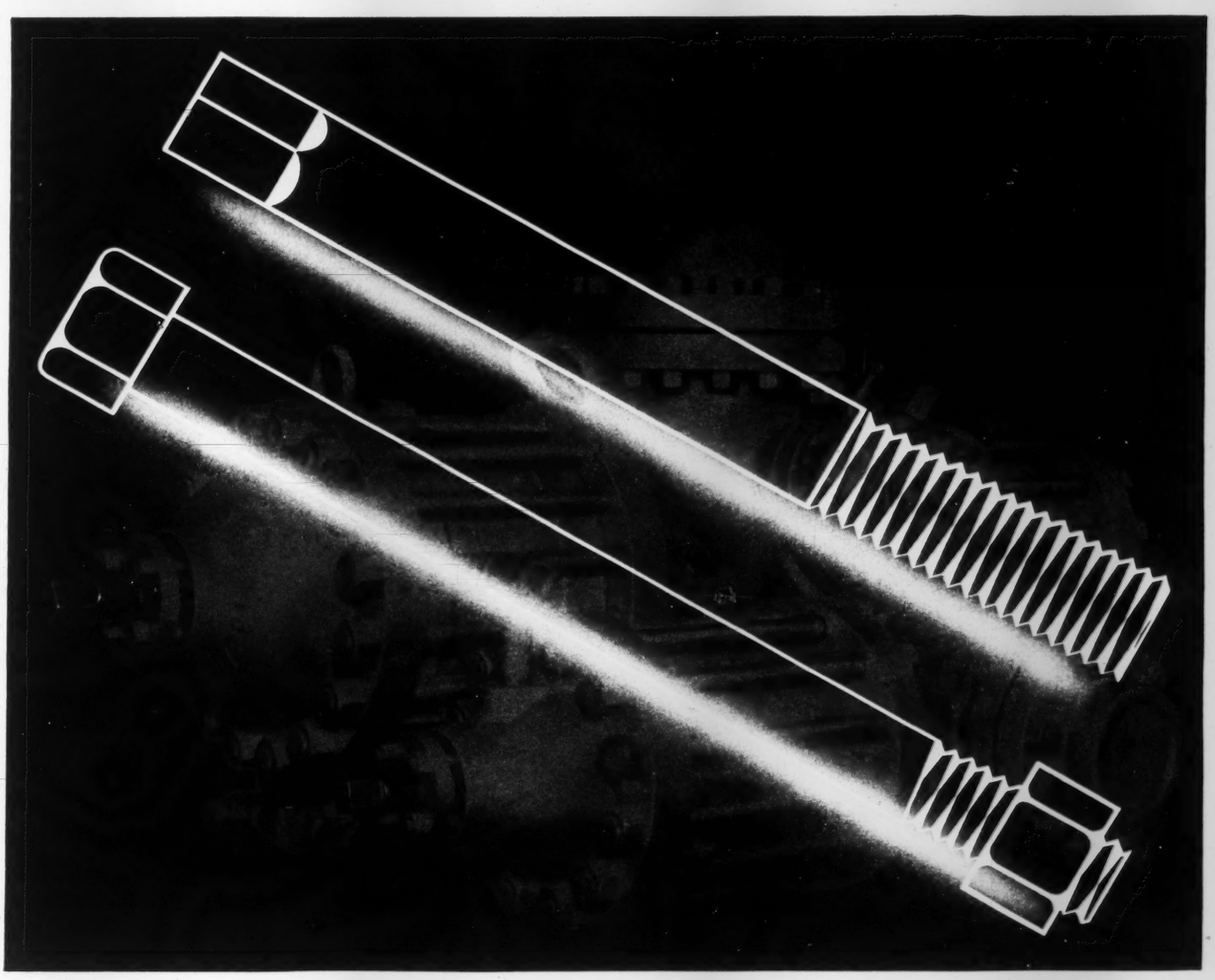
DISCUSSION

On previously published papers by R. W. Angus; R. T. Knapp; L. W. Wallace and G. G. Early; F. M. Wood; T. D. Perry and M. F. Bretl; F. P. Zimmerli; R. Eksergian; and R. A. Sherman and J. M. Pilcher

Necrology

THE deaths of the following members have recently been reported to the office of the Society:

BINSSE, HENRY B., July 2, 1938
BROOME, ERNEST L., September 10, 1938
CAHILL, CHARLES A., October 5, 1938
CARSE, DAVID B., October 30, 1938
CRAVENS, GEORGE W., September 27, 1938
FLEMING, HENRY S., October 19, 1938
GRANGER, ABBOTT D., September 27, 1938
HARDING, FRANK W., September 29, 1938
HOLT, J. HUNT, August 13, 1938
JONES, EDWARD H., February 14, 1938
RABLE, HANS, September 2, 1938
SCHOENBORN, WILLIAM E., June 5, 1938
SMITH, FERDINAND L., October 18, 1938
STURKEN, CARL A., October 13, 1938



WHERE HIGH PRESSURE MUST BE CONTROLLED

When oil drilling encounters pressures of several thousand pounds per square inch, there must be no "ifs" or "buts" about the blow-out preventer's capacity to hold things in check. In one particular type of blow-out preventer (6000-pound test), thrust screw and head bolts play a vital part in preventing accidents and waste. They are made of Chrome-Moly (S.A.E. 4140) steel because:

(a) Chrome-Moly bolt stock can be heat treated in tonnage lots with perfect assurance of consistently developing the combined strength and toughness to withstand heavy loads and to prevent threads from stripping.

(b) Chrome-Moly bolts are readily machinable after heat treating.

Bolt and parts manufacturers seeking to speed up and simplify production, reduce costs, and still give their customers a better product, should send for our free book, ***"Molybdenum in Steel."*** Climax Molybdenum Company, 500 Fifth Avenue, New York.

PRODUCERS OF FERRO-MOLYBDENUM, CALCIUM MOLYBDATE AND MOLYBDENUM TRIOXIDE

Climax Mo-lyb-den-um Company

MOLY

•Keep Informed . . .

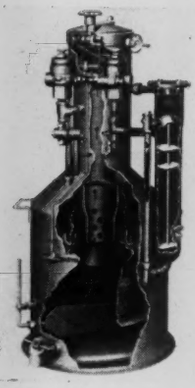
Available literature may be secured by addressing a request to the Advertising Department of MECHANICAL ENGINEERING or by writing direct to the manufacturer and mentioning MECHANICAL ENGINEERING as a source.

- *NEW EQUIPMENT*
- *BUSINESS CHANGES*
- *LATEST CATALOGS*

Announcements from current advertisers in MECHANICAL ENGINEERING and the A.S.M.E. MECHANICAL CATALOG

• NEW EQUIPMENT

Portable Medium-Pressure Acetylene Generator



The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation, 205 East 42nd Street, New York, N. Y., has announced a new, portable acetylene generator, developed for the user of small quantities of acetylene for oxy-acetylene welding and cutting.

This new generator, the Carbic Medium Pressure Acetylene Generator (Type CMP-2) utilizes the unique advantages of Carbic processed calcium carbide. Like all Cubic generators it makes available a dependable supply of acetylene, generated as required. It takes eight cakes of Carbic processed carbide at a single charge, and yields approximately 80 cu. ft. of acetylene from one charging.

The outstanding feature of the new CMP-2 generator is the rubber sealing cone which automatically seals off the cake holder from the water shell when the generator is not in use. This assures the most economical use of the charge of carbide, and prevents the generation of acetylene when it is not needed.

New Explosion-Proof Motors

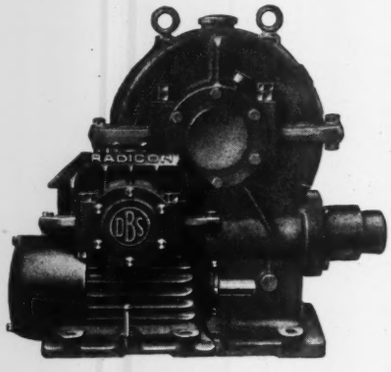
A new line of explosion-proof ball-bearing motors has been announced by Fairbanks, Morse & Co. These motors, approved by Underwriters' Laboratories for Class I Group D hazardous locations, insure against accidental ignition or explosion of vapors or gases which are prevalent in plants producing or employing gasoline, acetone, alcohols, volatile oils or combustible gases.

F-M explosion-proof motors are built in NEMA frames and can be applied to pumps, blowers, production machines, etc., as easily as any standard open motor. Double-end ventilation is one of the many exclusive features built into these new F-M motors. This feature assures positive cooling from both ends of the motor and eliminates "hot spots," thus adding to the life of the motor windings.

The construction and many features of this new line of F-M explosion-proof motors are fully described in Bulletin 1225, available free upon request from Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago, Illinois.

Radical New Worm Reducer

Thomas Prosser & Son, 120 Wall Street, New York, N. Y., dealers in fine steels, machinery, and mechanical specialities since 1849, announce that they have been appointed exclusive distributors for the United States of the "Radicon" Worm Reducer, which was developed by David Brown & Sons of Huddersfield, England, largest general gear manufacturers in the world. It is claimed that the Radicon Reducer is the most outstanding development in worm gearing since 1903, and has created a new standard of efficiency in worm gear performance. The safe rating of the Radicon Reducer is so tremendously increased that a 30% reduction in size is possible for any given duty, resulting in lower first cost. Its 50% reduction in oil drag gives increased efficiency and lower running cost. Automatic oil circulation eliminates all need for attention and maintenance costs. The Radicon Reducer is the result of years of extensive study, research, and experiment. It was designed for maximum load capacity, wear, and dependability.



All bearings in the Radicon Reducer are positively lubricated. A continuous oil circulating system, effective from the lowest speeds, works in both directions of rotation and provides positive automatic lubrication. Leakage is prevented by double-wall oil baffles and flingers. The Radicon Reducer requires no attention for months on end.

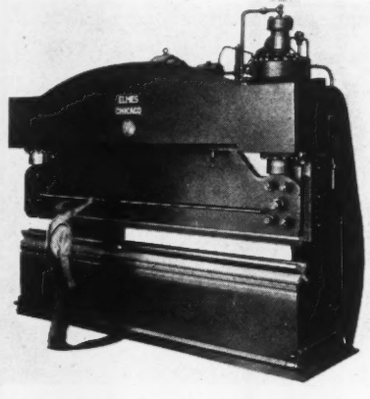
Efficient cooling is the dominant factor in the great increase in load carrying capacity achieved by the Radicon Reducer. All processes of heat transference are employed—Radiation (due to great increase in surface area)—Convection (convection from upper housing resulting from vertical ribbing)—Conduction (by fan projecting a stream of cold high velocity air along the horizontal channels). The patented shape of gear tooth, in conjunction with the special cooling methods, insures that higher powers are possible with normal temperature rise. It is claimed that up to 100% increase in load carrying capacity is achieved by the Radicon Reducer.

Mr. Wilfred Duxbury, who has been in charge of the Gear Department of David Brown & Sons in England, has joined the staff of Thomas Prosser & Son, and his complete knowledge of every phase of the business, together with the facilities of the engineering staff of Thomas Prosser & Son, is now available to American industry. A complete stock of various sizes of Radicon Reducers is carried for immediate delivery. Cone-ring patented couplings and base plates are also available. Catalogs and complete information will be furnished on application.

A New Hydraulic Bending Brake

Anyone interested in the bending and forming of sheet metal will be interested in the new Hydraulic Bending Brake being introduced by the Charles F. Elmes Engineering Works, 215 North Morgan St., Chicago, Ill. This Brake is a new departure from anything before offered, and affords economy, simplicity, faster production, greater safety, and numerous other advantages in operation. With the hydraulic type of Brake it is impossible to damage the machine by attempting to handle work beyond its capacity. The Brake will simply come down on the work, build up its maximum rated pressure, at which time an automatic valve opens, allowing the excess pressure to be returned to the oil reservoir.

It is unnecessary to make stroke adjustments for handling varying thicknesses of material since the bending beam continues in its downward motion as long as the operator depressed the foot pedal. Release of the foot pedal immediately reverses the movement of the bending beam, returning it to its normal position. The bending beam travels to the work at a rapid advance speed, automatically slowing down for the actual bending or forming operation thereby giving the operator a chance to check the location



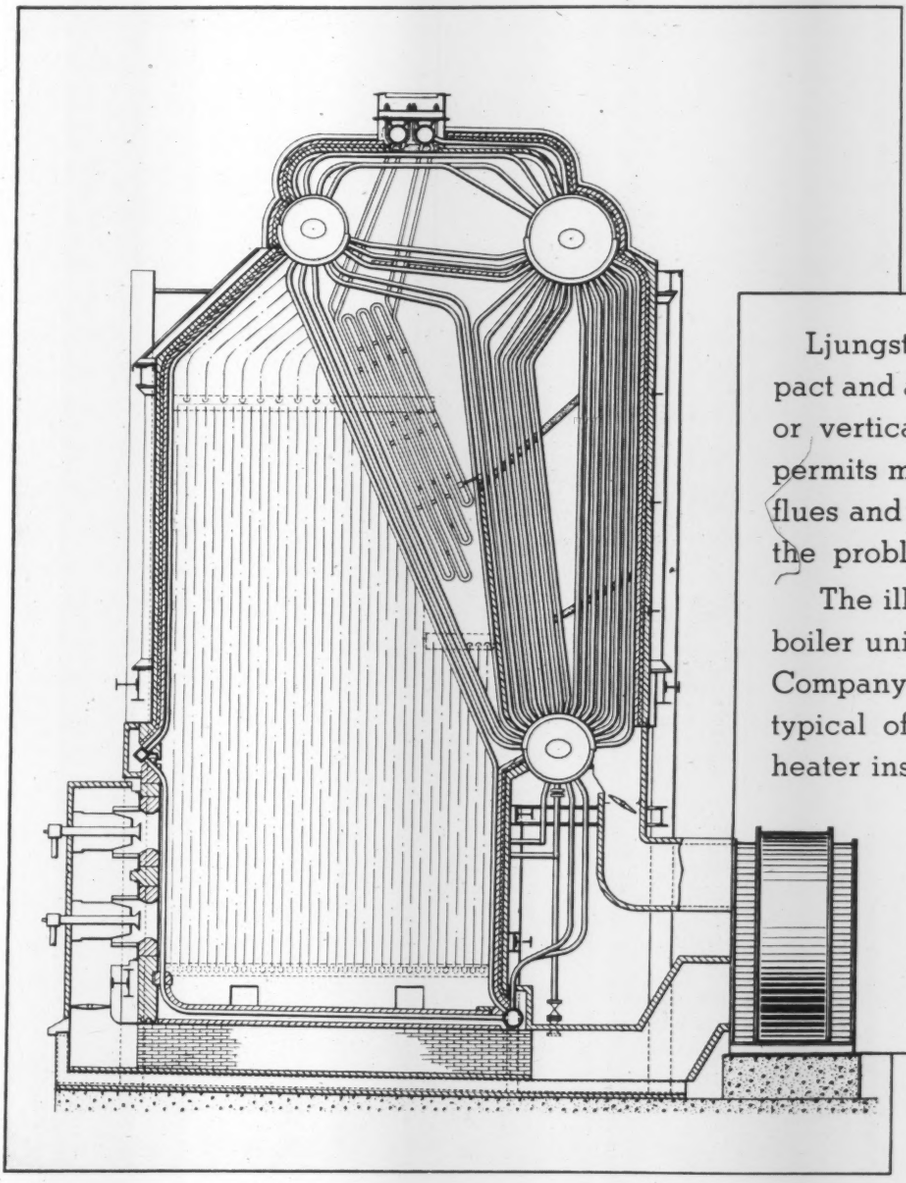
of the piece and angle of the bend. Movement of the bending beam can be stopped and held at any predetermined point by the operator while he checks his progress. The return movement of the bending beam is under fast traverse.

The travel of the two pistons which force the bending beam downward is so equalized

Continued on Page 14

ADAPTABILITY

Ljungström Air Preheaters Simplify Design Problems In the Boiler Plant



Ljungström air preheaters are compact and adaptable to either horizontal or vertical flow of gas and air. This permits minimum installation costs for flues and ducts, and greatly simplifies the problems of boiler plant design.

The illustration of one of the three boiler units for the plant of The Texas Company at Port Arthur, Texas, is typical of many Ljungström air preheater installations.

Low initial cost is followed by correspondingly reduced maintenance charges and radiation losses during daily operation.

THE AIR PREHEATER CORPORATION

Under the Management of THE SUPERHEATER CO.

60 East 42nd Street New York, N. Y.

A-1262

Continued from page 12

that it remains constant, regardless of eccentric loading. This equalizing feature (patent applied for) permits the forming or bending to be done at any point on the Bed. The downward rapid advance speed as well as the actual working speed can be quickly adjusted from zero to the maximum speed of which the machine is capable. This adjusting feature permits difficult forming work at a slow enough speed to allow the metal to flow—thereby eliminating tearing. An adjusting mechanism is located on the side of the machine making it possible to quickly adjust the upward stroke of the bending beam stopping at any desired point, eliminating the idle stroke on production work.

A unique safety feature makes it impossible to drop the bending beam when the motor is not in operation. Therefore when it is desired to change dies the operator can work in safety by simply stopping the motor. This Brake has among its many desirable features, greater depth of throat and opening than is customary in this type of machine. Its construction consists of welded steel housings, bed and beam, in which are mounted standard hydraulic units. This type of construction makes it possible to furnish practically any size or capacity of Brake that may be required. The bending beam is accurately guided on the welded steel housings, adjustable type guides being used. Pressure lubrication assures a minimum amount of wear on the guides. With the exception of the guides, no other lubrication is required since the Hydraulic Pump is of the self-lubricating type. No special dies are required for the Hydraulic Brake since it will accommodate the standard type of dies now in everyday use.

BARCO

CENTER-SPRING
STREAMLINED

FLEXIBLE BALL JOINTS

Long Life

Stainless steel spring shrouded for protection against fluids, corrosion and erosion.

Spring pressure against ball in exact center, providing equal pressure of ball against gasket seat in all positions with minimum friction.

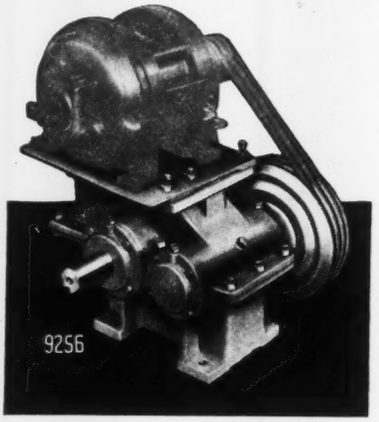
Automatic adjustment.

Catalog 320 will give you the complete details.

BARCO MANUFACTURING CO. 1811 WINNEMAC AVE. CHICAGO, ILL.

Saco Speed Reducers

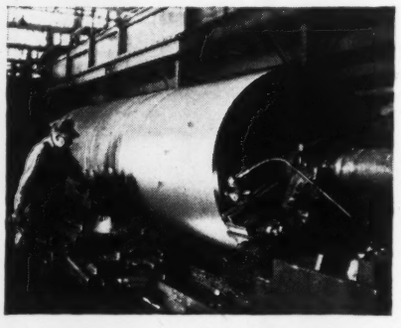
Stephens-Adamson Mfg. Co., 450 Ridgeway Ave., Aurora, Illinois, have added to their well known line of J.F.S. Variable Speed Reducers, a new line of constant speed reducers to be advertised and sold under the trade name, SACO. (Factories also at Belleville, Ontario and Los Angeles, Calif.)



SACO Speed Reducers can be used with any standard, full speed motor to give required output speed. The motor support is adjustable for V-belt drive, permitting sheaves to be replaced with ease to suit changes in required output speed. The shaft support construction of the SACO Speed Reducer permits heavy over-hung load. The wide range of output speed varies from 13.2 R.P.M. to 172 R.P.M. The high efficiency of SACO Reducers runs from 89 to 93%.

All shafts are mounted in precision ball bearings and the precision cut helical steel gears operate in a constant bath of oil. Application of the new SACO Reducers is literally universal. While Stephens-Adamson features these new Reducers with their REDLER Conveyor-Elevators, Belt Conveyors, Feeders, Elevators and Screw Conveyors, they can be used with any constant speed driven machine within the SACO output speed range. Bulletin #7638 will be sent upon request.

2½ Miles of Cutting



This cast iron roll, 5 ft. in diameter and 18 ft. long, is rough turned, faced, and bored with Haynes Stellite-2400 tools. Both ends are bored, and the ends and inside shoulder are faced, while the outside diameter is being rough turned. Two tools are used for rough

Continued on Page 16

99 9,996,551/10,000,000 % OF CRANE SCREWED FITTINGS ARE FOUND FIT*

THE precise manufacturing methods that account for such a high standard of perfection in the production of Crane Screwed fittings are your assurance of superior performance—even in Crane fittings for the most common services. For greater piping satisfaction, specify Crane-Equipment throughout, because—in fittings as in valves—

IT'S WHAT'S INSIDE THAT COUNTS!

CRANE

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

**Details in folder available upon request.*

CRANE CO., GENERAL OFFICES: 836 S. MICHIGAN AVE., CHICAGO, ILLINOIS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

CRANE SCREWED FITTINGS FOR POWER PLANTS AND FACTORIES

Crane's line of fittings includes not merely the few hundred types and sizes in most common use, but a total of more than 10,000 separate and distinct items in cast and malleable iron.

ELBOWS—90°, 67½°, 60°, 45°, 30°, 22½°, 11¼°, and 5⅝°, Street, Long Sweep, Side Outlet, Drop, Hub Vent

TEES—Service, Four-Way, Drop Tees, Long Sweep, Double Sweep, Wash Tray

COUPLINGS—Right Hand, Right and Left, Half (Also Wrought Iron), Reducers, Increasers

UNION FITTINGS—Mal and Female, 90° and 45° Elbows, Tees with Union or Run or Outlet

BUSHINGS—Outside and Inside Hexagon, Face, Eccentric, Double Tapped

PLUGS—Square Head, Solid, Countersunk, Bar, Barrel

NIPPLES—Close, Short, Long, Tank

UNIONS—Ground Joint Gasket Type, Female, Mal and Female, Air-Pump

A CRANE FITTING FOR EVERY PURPOSE—The screwed fittings shown above are only a few of the scores of different types and modifications. The complete Crane line includes banded and plain patterns, black or galvanized, in a wide range of straight and reducing sizes, in four pressure classes in malleable iron and five in cast iron.

Preview!

ENGINEERING AND INDUSTRIAL STANDARDS

Notes on the Development of American Standards

to be published by the A.S.M.E.

The 1938 Annual Report of the A.S.M.E. Technical Committees is available to interested executives. Do you wish a copy?

SCIENTIFIC and ENGINEERING GRAPHS

The subcommitee which has been at work on a proposed American Standard for Scientific and Engineering Graphs intended for use in publications has practically completed a tentative draft of its report which is soon to be distributed, in a limited quantity, for criticism and comment.

SCREW THREAD GAGING

A meeting of the Sectional Committee on the Standardization and Unification of Screw Threads is to be held during the Annual Meeting of the ASME in New York, December 5-9. It is expected that important decisions regarding the form of the proposed standard practice for screw thread gaging are to be made at that meeting.

CAST-IRON THREADED PIPE

Two sectional committees organized under the procedure of the American Standards Association, namely, that on Cast-Iron Pressure Pipe and the one on Plumbing Equipment, are planning to cooperate in the development of an American Standard for Threaded Cast-Iron Pipe. The members of the joint committee are now being named.

• Keep Informed . . .

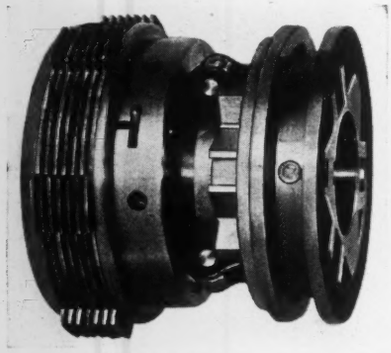
Continued from page 14

turning. The first takes a 1/4 in. depth of cut and the second takes 1/8 in. depth of cut. The surface speed is 85 ft. per min., and the feed is 1/4 in. per rev. Under these conditions, it is calculated that the rough turning tools cut a distance of slightly over 13,500 ft.—2 1/2 miles on each roll. Two rolls are turned per tool grind.

Observe, particularly, the angle of the tool holder block. This angle is necessary to assure a shear cut on such large stock. The cutting edge of the tool is approximately 7 in. above center.

New Twin Disc Clutch Model

A new model of Multiple Disc type Clutches designed for machine tool and other installations where space is limited has recently been put on the market by Twin Disc Clutch Company, 1322 Racine Street, Racine, Wisconsin.



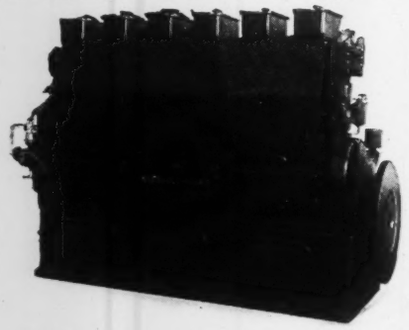
Known as Model MT, this new clutch has a greatly simplified design when compared to similar clutches for this work. It is said to cost somewhat less and because of its different action, has an easier, smoother, engagement and release with less engaging pressure.

The Model MT Clutch is available in nine different sizes, ranging from 3″ in diameter to 8″, in single or duplex units, to run dry or in oil. Minute adjustments on all sizes can be made from a single point to give maximum capacity from minimum lever pressure.

• LATEST CATALOGS

New Diesel Catalog

A new forty page bulletin on Type "S" Diesel Engines has just been published by Ingersoll-Rand. This machine is a heavy-duty, continuous-service, compact engine for stationary or marine-electric application.



It is a four-cycle, single-acting, solid-injection engine of the modern enclosed type having complete force-feed lubrication, wet liners, shell bearings, and many other refinements. Of particular interest is the low fuel consumption of 0.38 lbs. per BHP Hr at full load. The fuel injection system has an individual fuel pump for each cylinder and there are two single-acting non-clogging nozzles per cylinder.

The Type "S" Engine is built in sizes of 3,4,5,6,7 and 8 cylinders, and rated at 175, 230, 290, 350, 405 and 460 BHP, respectively, for 600 revolutions per minute.

The bulletin contains many illustrations of the engine parts, explaining the relationship of their design to the economical installation and operation characteristics of the unit. Several pages are devoted to application views on a variety of services in various parts of the world. In addition, specifications, dimensions, cut-away views and other information are contained in the catalog, form 10110, copies of which are obtainable from the Ingersoll-Rand Company, 11 Broadway, New York, N. Y., or any of their branch offices.

Hydraulic Pumps

Just issued by John Robertson Company, 121–137 Water Street, Brooklyn, N. Y.—a new bulletin on Robertson High Pressure Hydraulic Pumps. This bulletin, a convenient file-size folder, contains a detailed description of the construction of these pumps (including the "14 famous advantages" designed to lower operating and maintenance costs); incorporates a complete reference table of general dimensions and specifications. Copy may be obtained free by writing Dept. D.

Solenoid Valves

Davis Regulator Co., 2545 S. Washtenaw Ave., Chicago, Ill., offers readers copies of new bulletin No. S-1, illustrating and describing Davis solenoid valves which can be used for automatic control service on heating systems, container filling equipment, feed-water make-up lines, refrigeration systems, boiler feed fuel lines, etc. The types listed are for general service on steam, air, gas and liquid.

DeLaval Opposed Impeller Series Pumps

Opposed impeller series pumps, in which two single suction impellers are mounted with the suction openings facing in opposite directions towards the end of the shaft, are described in Catalog B-3, issued by the De Laval Steam Turbine Co., Trenton, N. J. In this type of pump not only is the impeller balanced hydraulically, but only two pairs of wearing rings are needed, the same as for a single-stage pump. Leakage from the second stage to the first stage is reduced by a labyrinth shaft sleeve and the fact that the short, stiff shaft requires only small clearance.

Pulverized Coal

"C-E Direct Fired Systems for Burning Pulverized Coal" is the title of a new 36-page catalog issued by Combustion Engineering Company, Inc., 200 Madison Ave., New York, N. Y. It contains a synopsis of the development of pulverized coal firing and its influence on the capacities and designs of steam generating units. The section on mills describes both the impact and the bowl mill types for direct firing. That on burners deals with tangential corner firing, vertical firing and horizontal turbulent burners. Mill feeders are also described and considerable space is given to a discussion of furnaces for burning pulverized coal. The 53 illustrations include, in addition to details of mills, feeders and burners, numerous in-

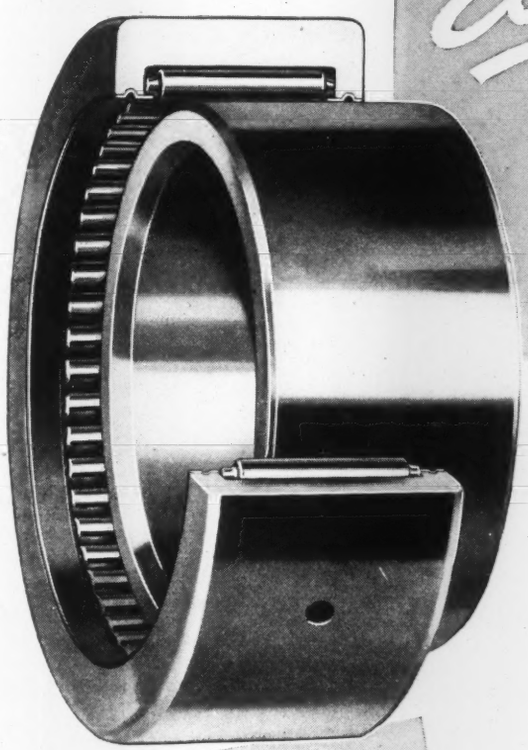
Continued on Page 18

New Type — BANTAM QUILL BEARING!

Excels WHERE LOADS ARE HEAVIEST

WHERE RELIABILITY IS PARAMOUNT

WHERE LOWER COSTS ARE ESSENTIAL



WIDE RANGE OF SIZES CARRIED IN STOCK!

HERE'S the answer to your need for a bearing which takes less space, has high load capacity, yet sells at a low price. Bantam Standard Series Quill Bearings are the result of years of pioneering in the production of Quill and Needle Bearings and offer many advantages. Design has been greatly simplified. No fragile parts, thereby avoiding possibility of failure. End Thrust is taken on ribs of the one-piece channel-shaped outer race.

Bantam Standard Quill Bearings are available for immediate delivery in shaft sizes from ½" to 5".

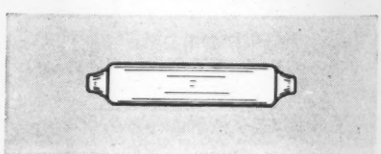
Full Engineering Data on Bantam Standard Series Quill Bearing is available. Send today for Bulletin 103 N.

For Needle Bearings to be used in lighter service request Circular 19A from our affiliate, The Torrington Company, Torrington, Conn.

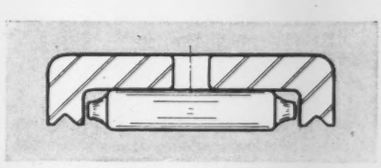
BANTAM BEARINGS CORPORATION
SOUTH BEND, INDIANA
Subsidiary of THE TORRINGTON CO.
Torrington, Conn.

BANTAM BEARINGS

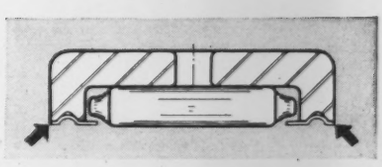
A complete range of sizes for shafts from ½" to 5" diameter is carried in stock ready for immediate shipment. Available with or without inner races.



Correctly proportioned rollers with husky curvilinear trunnions eliminating high stresses on trunnions. Accurately hardened and ground for long life.



One-piece channel-shaped outer race. Rigid surfaces all accurately hardened and ground providing solid abutment for end of roller. Assures longer bearing life.



All fragile parts have been eliminated. Simplified method for definite roller retainment. Function of the retaining band is completed when bearing is assembled.

TAPERED ROLLER • • • STRAIGHT ROLLER • • • BALL BEARINGS

PROFESSIONAL SERVICE

in ALL BRANCHES of the ENGINEERING FIELD

Consulting Engineers
Engineering Organizations
Constructors—Contractors
Patent Lawyers—Etc.

Water Conditioning—Consultants on ALL water problems. Plant Studies and Research on reasonable fee basis. Preliminary discussion without obligation.

W. H. & L. D. BETZ
235 W. Wyoming Avenue, Philadelphia, Pa.

Smoke Abatement. Air Pollution. Combustion. Industrial Hygiene. Fuels and Steam Power.

WILLIAM G. CHRISTY, M.E.
ARTHUR CECIL STERN, M.E., M.S.
Office and Laboratories
928 Broadway New York, N. Y.

Patent Lawyers, U. S. & Foreign Patents and Trade Marks. Practice in the Patent Office and Courts. Mechanical, chemical and electrical applications, novelty searches, validity and infringement investigations, litigation.

EMERY, BOOTH, HOLCOMBE & MILLER
Munsey Building Washington, D. C.

Power Plants. Superposed or Topping Power for Industry. Reports, designs, operation.

EDWARD R. FEICHT
Bala-Cynwyd, Pa. (outside Philadelphia)

Weld Testing—Qualification of Operators—Supervision—Inspection—Research.

NATIONAL WELD TESTING BUREAU
Pittsburgh Testing Laboratory, Pittsburgh, Pa.

Patent Attorney (Registered) Patents and Trade Marks. Consulting service in scientific and designing problems. Mechanical and Electrical Engineer.

JOHN P. NIKONOW
551 Fifth Ave., New York, N. Y.

Water Chemists and Engineers. Specialists in the Conditioning of Boiler Feed Water. Chemical Analysis. Purification Methods. Treating Methods. Supply Methods.

CYRUS WM. RICE & CO., INC.
Highland Bldg., Pittsburgh, Pa.

Power Plants, Structures, Transmission Systems—Design Supervision, Inspection, Appraisals, Reports.

SARGENT & LUNDY
140 S. Dearborn St., Chicago, Ill.

Patent Lawyer—Patents and Trade Marks

HENRY H. SNELLING
McGill Bldg., Washington, D. C.

Power Plants. Surveys, design, construction, supervision. Combustion.

JOHN A. STEVENS, INC.
16 Shattuck St., Lowell, Mass.

RATE Announcements under this heading in MECHANICAL ENGINEERING are inserted at the flat rate of $1.25 a line per issue, $1.00 a line to A.S.M.E. members, minimum charge, three line basis. Uniform style set-up. Copy must be in hand not later than the 10th of the month preceding date of publication.

• Keep Informed . . .

Continued from page 16

stallation views covering the application of pulverized coal to different boiler types and a wide range in size of boilers as installed in various industries throughout the country.

Farrel-Birmingham Issues Latest Information on Gears

Valuable information on the various types of speed reducing and speed increasing gear units and related products manufactured by Farrel-Birmingham Company, Inc., Buffalo, N. Y., is contained in a new 80-page illustrated catalog just published by the company.

This catalog discusses herringbone gears and their advantages for transmitting power and transforming speed between parallel shafts. It explains how the introduction of the Sykes process for generating continuous herringbone teeth and its development by the Farrel-Birmingham Company opened the way to an enormous expansion in the use of herringbone gears for nearly every conceivable application.

The new catalog contains twenty illustrated pages describing a complete series of gear units of the speed reducing type, accompanied by tables of horsepower ratings, service factors, overhung load capacities, dimensions and weights. Similar descriptive and engineering data are given on speed increasing units, vertical reduction units of the horizontal shaft type and right angle vertical shaft drives.

In addition, many special purpose units are illustrated and described. Among these are high-ratio drives, multi-speed gear units, right angle horizontal shaft units, rolling mill drives and pinion stands, dredge drives and marine propulsion units. Data on Gearflex Couplings of the double engagement type, which are used for connecting the gear units with their driving motors and driven machines, are also given.

There is also included a description of the machines and process by which the continuous tooth herringbone gears are generated; an instructive chapter on gear design and many photographic illustrations of Farrel-Sykes gear installations.

The catalog is beautifully printed in clear, readable type in black ink on white coated paper and has a scarlet cover printed with a distinctive design in black and silver. It has 114 fine halftone illustrations, 16 line diagrams and 46 charts and tables. It is "Roto" wire bound and punched for standard three-ring binder for convenience in use and filing.

It is an engineering handbook which will be found useful by all who design, specify, buy or use gear units.

Complimentary copies may be secured by plant executives and engineers who write to Farrel-Birmingham Company, Inc., 344 Vulcan St., Buffalo, N. Y., for Catalog 438.

Rotary Condensation Meter

How to meter steam accurately in the form of condensate is the subject of a revised 12 page Bulletin No. 35-80A on the ADSCO Rotary Condensation Meter. It illustrates and describes the meter, gives details of construction, operation, installation diagrams, typical installation photographs and a partial list of users in the industrial, college, institutional and public utility fields. A copy of the bulletin may be obtained by addressing the American District Steam Co., North Tonawanda, N. Y.

Continuous Blowdown System

Elgin Softener Corporation, Elgin, Illinois, has recently issued a new bulletin No. 510 which presents a treatise on the subject of continuous blowdown systems for steam boiler plants. The need for such systems is illustrated by typical plant studies with useful charts and tables. The latter also point out savings to be realized with heat exchangers. A new useful treatise on an old subject.

Bearings, Bushings, Etc.

What do you know about bearings, bearing liners, bushings, babbitt metals and bronze bars? A new book, just published by the Federal-Mogul Corporation, 822 Shoemaker Ave., Detroit, Mich., profusely illustrates and describes the various types of engine bearings, bearing liners and bushings in general use, the newer types now coming into wider use, and the methods of design and manufacture which are important influences in the price you pay and the performance you obtain.

The more you know about modern bearing design, modern alloys, and today's methods of manufacture, the better can you design or buy bearings and bushings. This book can help both machine designer and the bearing buyer accomplish these things.

It illustrates a wide variety of modern bearing and bushing applications on machines and appliances. It discusses the advantages of applying designs and alloys developed in automotive practice to modern machines. With a background of forty years' experience in this field, and maintaining one of the most extensive chemical, metallurgical and engineering research laboratories in the world devoted to bearings and bushings, Federal-Mogul is particularly well suited to discuss this subject.

COMING MEETINGS AND EXPOSITIONS

For the next three months

DECEMBER

1–2	Society of Naval Architects and Marine Engineers, 46th Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.
5–9	The American Society of Mechanical Engineers, Annual Meeting, New York, N. Y.
5-10	Thirteenth National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York, N. Y.
6–8	American Society of Refrigerating Engineers, 34th Annual Meeting, Hotel Commodore, New York, N.Y.
27–28	Institute of Aeronautical Sciences, Technical Meeting, Richmond, Va.
27–31	American Association for the Advancement of Science, Winter Meeting, Richmond, Va.

JANUARY 1939

9–13	Society of Automotive Engineers, Annual Meeting, Detroit, Mich.
15–17	National Aeronautic Association, Annual Convention, St. Louis, Mo.
18–21	American Society of Civil Engineers, Annual Meeting, New York, N. Y.
23–26	American Society of Heating and Ventilating Engineers, Annual Meeting, William Penn Hotel, Pittsburgh, Pa.
23–27	American Institute of Electrical Engineers, Winter Convention, New York, N. Y.
23–27	Institute of the Aeronautical Sciences, Annual Meeting, Columbia University, New York, N. Y.

FEBRUARY

8 9	Steel Founders' Society of America, Cleveland, Ohio.
13–16	American Institute of Mining and Metallurgical Engineers, Annual Meeting, New York, N. Y.

PRESS SEIZING Stopped! Lubrication Time Cut 75%

Another Victory for LUBRIPLATE LUBRICANTS . . . this time at The National Lock Washer Company, Newark, N. J.

STOP PRODUCTION and tear down equipment to make frequent repairs? Not in The National Lock Washer Company of Newark, N. J.! Five years ago this company discovered that Lubriplate No. 100 would stop the "scoring" and consequent "seizing" in the slides of automatic wire forming machines. They learned too, that one oiling daily—instead of four—would do the job. Now National Lock Washer uses Lubriplate in practically every lubrication task throughout the plant. Reason? If Lubriplate can do the tough jobs—it can certainly do the easy ones. As for costs, they're lower. With Lubriplate, less lubricant does more!

MAKE US PROVE THIS:

We say that Lubriplate will solve any lubrication problem—the tougher the better. Why not do just as The National Lock Washer Company did, and make us prove it? You can—and without the slightest cost. You merely tell us what you're up against—the problem that causes you the most headaches. We supply you with enough Lubriplate of the proper grade to test in your own plant, under your own operating conditions. Tell us that problem today—and make it tough!

7 QUICK FACTS ABOUT LUBRIPLATE LUBRICANTS

1. Produces a wear resistant film on working surfaces.
2. Resists rust, corrosion and pitting.
3. Lowers maintenance and power costs.
4. Lubriplate is white and clean.
5. Outlasts ordinary lubricants many times.
6. Cheapest in the long run. A little goes a long ways.
7. Available in fluid and grease types for your every need.

THERE IS A LUBRIPLATE DISTRIBUTOR NEAR YOU

APPLETON, WISC.
Schlafer Supply Co.
ASHEVILLE, N. C.
Tidewater Supply Company, Inc
ATLANTA, GA.
Chears Company
BALTIMORE, MD.
L. A. Benson Co., Inc.
BANGOR, ME.
Chase, Parker & Co., Ernest Wood, Representative
BINGHAMTON, N. Y.
Ellis W. Morse Co.
BIRMINGHAM, ALA.
Jefferson Brick Supply Co.
BOSTON, MASS.
Chase, Parker & Co.
BRIDGEPORT, CONN.
Hunter & Havens, Inc.
BUFFALO, N. Y.
J. R. Sullivan (Representative) 28—15th St.
BUTTE, MONT.
Montana Hardware Co.
CHARLOTTE, N. C.
H. T. Sedgwick (Representative) 301 Poplar Apartments
CHATTANOOGA, TENN.
Noland Company
CHICAGO, ILL.
Metal Lubricants Co.
CINCINNATI, O.
Cincinnati-Vulcan Co.
CLEVELAND, O.
J. R. McKee (Representative) 11821 Princeton Ave.
COLUMBIA, S. C.
Tidewater Supply Company, Inc.
DENVER, COLO.
M. L. Foss, Inc.
DETROIT, MICH.
Fiske Bros. Refining Co., General Motors Building
GASTONIA, N. C.
Gastonia Mill Supply Co.
GREAT FALLS, MONT.
Montana Hardware Co.
HARTFORD, CONN.
L. L. Ensworth & Son, Inc.
HELENA, ARK.
Lewis Supply Co.
HOLYOKE, MASS.
J. Russell & Co.
HUNTINGTON, W. VA.
Banks-Miller Supply Co.
KANSAS CITY, MO.
Essmueller Mill Furnishing Co.
LOS ANGELES, CAL.
L. A. Rubber & Asbestos Co.
MEMPHIS, TENN.
Lewis Supply Co.
MINNEAPOLIS, MINN.
McGlynn Oil Co.
MOBILE, ALA.
Turner Supply Co.
NEWARK, N. J.
Seither & Ellis, Inc.
NEW HAVEN, CONN.
Page, Steele & Flagg Co.
NEW ORLEANS, LA.
C. T. Patterson Co.
NEW YORK, N. Y.
Topping Brothers, Inc.
NORFOLK, VA.
Tidewater Supply Company, Inc
PASSAIC, N. J.
N. J. Engineering & Supp. Co.
PHILADELPHIA, PA.
Tristate Corporation
PITTSBURGH, PA.
R. G. Schenck (Representative) 614 Ridgefield Ave.
PORTLAND, ME.
Chase, Parker & Co., V. W. Everett, Representative, 104 Prospect St.
PORTLAND, ORE.
Goodyear Rubber & Asb. Co.
PROVIDENCE, R. I.
Farr & Read Company, Inc.
ROANOKE, VA.
Tidewater Supply Company, Inc
ROCHESTER, N. Y.
Sidney B. Roby Co.
SALT LAKE CITY, UTAH
Industrial Supply Co.
SAN FRANCISCO, CAL.
Miller & Stern Supply Co.
ST. LOUIS, MO.
Essmueller Mill Furnishing Co.
Industrial Lubricating Co.
SEATTLE, WASH.
Chas. H. Harden & Co.
SPOKANE, WASH.
Nott-Atwater Co.
SYRACUSE, N. Y.
Baldwin-Hall Co.
TOLEDO, O.
Fiske Brothers Refining Co. (Plant & Office)
TRENTON, N. J.
Standard Supply & Equip. Co.
TROY, N. Y.
Fred K. Blanchard, Inc.
UTICA, N. Y.
Central N. Y. Sales Co.
WATERTOWN, N. Y.
W. W. Conde Hardware Co.
WILMINGTON, DEL.
W. Floyd Jackson Co.
WINTER HAVEN, FLA.
V. G. Modena
YORK, PA.
Geo. F. Motter's Sons Supp. Co.

FISKE BROTHERS REFINING CO., Newark, N. J. • Toledo, Ohio

Let us hand you these . . .

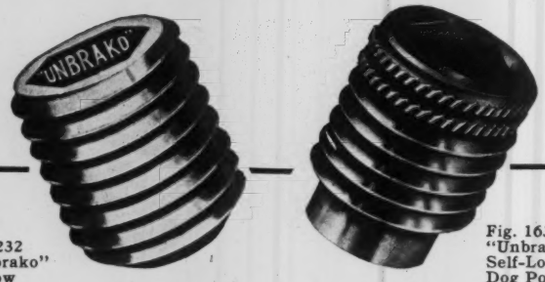


Fig. 232 "Unbrako" Hollow Set Screw

Fig. 1636 "Unbrako" Self-Locking Dog Point Set Screw Pat'd

UNBRAKO

SOCKET SCREWS

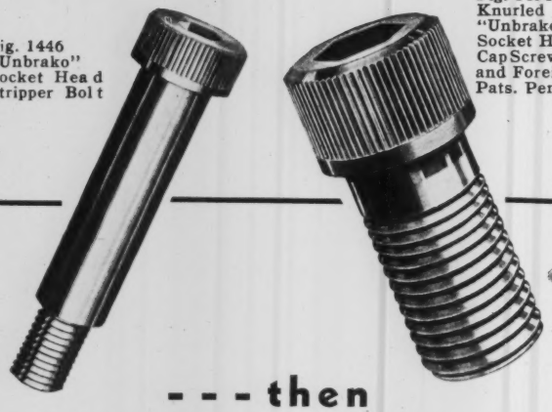


Fig. 1446 "Unbrako" Socket Head Stripper Bolt

Fig. 1434 Knurled "Unbrako" Socket Head Cap Screw, U.S. and Foreign Pats. Pending

- - - then you'll really appreciate their high quality!

So many men who have actually held these "Unbrako" Socket Screws in their hands have told us "YOU CAN UNDERSTAND BY JUST EXAMINING THEM THAT THEY ARE TOPS IN QUALITY," that we want you, too, to see for yourself that that statement is not an exaggeration. The fine machining, the sleek, dull black finish, the perfect balance and accurate threading are obvious quality indications.

Any tests you care to give them will show you that "Unbrakos" are unbelievably strong. You'll want to use them from then on. Write us and we'll send you samples as well as full information about the complete line.

Shown above are: "UNBRAKO" HOLLOW SET SCREW. A very strong screw that's been a favorite with mechanics and management for many years.

"UNBRAKO" SELF-LOCKING DOG POINT SET SCREW. The set screw that locks itself in place and never loosens until a wrench is applied. It can be used again and again.

KNURLED "UNBRAKO" SOCKET HEAD STRIPPER BOLT. The socket head is a great help for application in small spaces.

KNURLED "UNBRAKO" SOCKET HEAD CAP SCREW. Has several outstanding and distinctive advantages.

STANDARD PRESSED STEEL CO.

BRANCHES BOSTON DETROIT INDIANAPOLIS — JENKINTOWN, PENNA. Box 558 — BRANCHES CHICAGO ST. LOUIS SAN FRANCISCO

The Standards COLUMN

News of Interest to Manufacturers

Carriage and Step Bolt Standard under Revision

NOTWITHSTANDING the fact that very few carriages are manufactured these days in the United States, "carriage" and "step" bolts are produced by the hundred thousands each year. The reason is plain. They are used in the manufacture of automobiles, both private cars and commercial trucks, and in the manufacture of agricultural machinery.

The principle on which the several types of heads of these bolts are designed calls for a bolt with a head having a relatively low, smooth top together with a device to keep the bolt from turning when the nut is pulled up. At present this device consists of (1) a square under the head, (2) ribbing of the neck, or (3) fins connecting the head with the body on two opposite sides. Originally these squares, ribs, and fins were driven into the wood surrounding the bored hole and this is still the way the two types named last are used. Today, however, the square necked type is employed frequently to hold together metal parts and since these metal parts are often relatively thin the length of the square is made shorter than formerly.

This American Standard for Round Unslotted Head Bolts, B18.7, was completed, approved, and first published in February, 1928. The present revision was begun six and one-half years later in December, 1934. The purpose of this revision is to bring the standard into line with changed requirements on the part of the consumers and refinements in the manufacture of this type of bolt. Several dimensional changes have been made in the tables of the original standard and additional material included. A general table of thread lengths has been placed in the appendix to the standard and the individual thread length tables have been omitted.

Now that this proposed revision has received the approval of the members of Subcommittee No. 5 of which Mr. M. C. Horine is chairman, it will be presented to the members of the Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions, B18, Prof. A. E. Norton, chairman, for vote on approval by letter ballot. If the vote is favorable the proposal will then go to the Society of Automotive Engineers and The American Society of Mechanical Engineers for approval as joint sponsor societies and for transmittal to the American Standards Association with their recommendations concerning designation as an American Standard.

Sectional Committee B18 with its nine (9) subcommittees was organized on March 16, 1922. Since that date it has completed nine (9) standards and two (2) revisions of these standards all of which were approved and published.

For further information—address

The American Society of Mechanical Engineers
29 West 39th St., New York, N. Y.